U.S. ENVIRONMENTAL PROTECTION AGENCY
Region I, New England

RECORD OF DECISION
First Operable Unit--Source Control

ROSE HILL REGIONAL LANDFILL SUPERFUND SITE
SOUTH KINGSTOWN, RHODE ISLAND
EPA ID # RID980521025

December, 1999

DECLARATION

ROSE HILL REGIONAL LANDFILL SUPERFUND SITE
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STATEMENT OF BASIS AND PURPOSE

This decision document presents the Selected Remedy for the Rose Hill Regional Landfill Superfund Site, in South Kingstown, Rhode Island, which was chosen in accordance with the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), and, to the extent practicable, the National Oil and Hazardous Substances Contingency Plan (NCP). This decision document represents the first operable unit of a phased approach to remediate the environmental contamination caused by the Site. The first operable unit is a source control remedy which is intended to prevent or minimize the continued release of hazardous substances, pollutants or contaminants to the environment. The first operable unit will collect data to assess the effectiveness of the source control remedy, assess the need for taking any further response actions under a second operable unit, and assist the State with TMDL predictions for Site-related contaminant concentrations affecting local water bodies. Management of the migration of contaminants to surface or ground water will be based on data obtained from monitoring conducted under the first operable unit and any additional studies that are deemed necessary to further assess Site impacts, characterize the extent of contamination, and assess the need to develop and evaluate alternatives for future actions.

This decision is based on the Administrative Record which has been developed in accordance with Section 113(k) of CERCLA and which is available for public review at the South Kingstown Public Library in Peace Dale, Rhode Island and at the USEPA Region I -New England, Office of Site Remediation and Restoration Records Center in Boston, Massachusetts. The Administrative Record Index identifies each of the items comprising the Administrative Record upon which the selection of the remedial action is based. The Administrative Record Index is Appendix B of this Record of Decision (ROD).

The Rhode Island Department of Environmental Management has reviewed the various alternatives and has indicated its support for the selected remedy. The State has also reviewed the Remedial Investigation, Risk Assessment and Feasibility Study to determine if the selected remedy is in compliance with applicable or relevant and appropriate State Environmental laws and regulations. The State of Rhode Island concurs with the selected remedy for the Rose Hill Regional Landfill Superfund Site.

ASSESSMENT OF THE SITE

The response action selected in this ROD is necessary to protect the public health, welfare, or the environment. The human health and ecological risk assessments identified unacceptable risks posed by actual or threatened releases of hazardous substances from this Site which if not addressed by implementing the response action selected in this ROD, may present an imminent and substantial endangerment to public health, welfare, or the environment. Groundwater (through the use of institutional controls), air (through the collection and treatment of landfill gas) and leachate (through excavation and consolidation) are the media of focus for this operable unit response.

DESCRIPTION OF THE SELECTED REMEDY

The Selected Remedy is Alternative 4B, modified to take into account its role as the first operable unit of a phased approach to remediate the environmental contamination caused by the Site. The Selected Remedy consists of the following activities:

- **Alternative 4B:** *Consolidation of the Bulky Waste Area onto the Solid Waste Area, Containment, Leachate Collection and Treatment (during consolidation), and Landfill Gas Treatment (Solid Waste Area)*

    1. Excavate and consolidate the Bulky Waste Area landfill materials onto the Solid Waste Area landfill;

    2. Collect and effectively manage leachate and waters collected from runoff and de-watering operations during the excavation of the Bulky Waste Area ;

    3. Construct a multi-layer hazardous waste cap using innovative and cost efficient cover materials, as may be appropriate and as further defined in design, over the extent of the Solid Waste Area landfill and consolidated Bulky Waste Area materials;

    4. Inspect and monitor the integrity and performance of the landfill cap over time;

    5. Assess, control, collect, and treat landfill gas emissions by an active internal and perimeter gas collection system and thermal treatment of such gasses through the use of an enclosed flare and continue monitoring landfill gas concentrations to assess the need to modify the landfill gas collection treatment system as necessary;

    6. Implement access restrictions and Institutional Controls (land title restrictions including, but not limited to, easements and restrictive covenants) on land use and the use of, or hydraulic alteration of, groundwater where Preliminary Remediation Goals (PRGs) (based on MCLs, MCLGs) and/or other health based standards are exceeded.

    7. Install a chain link fence and/or other physical barriers where necessary to prevent

Site access, injury and/or exposure;

8. Long-term monitoring of surface water, groundwater, air and leachate emergence;

9. Perform operation and maintenance activities throughout the life of the remedy;

10. Conduct statutory five year reviews as required.

Estimated Time for Design and Construction:	*2 years*
Estimated Time of Operation:	*<15 years for LFG; >30 years GW/Leachate*
Estimated Capital Cost:	*$11,360,000*
Estimated Operations and Maintenance Costs ***(net present worth):***	*$6,680,000*
Estimated Total Cost ***(net present worth):***	*$18,040,000*

STATUTORY DETERMINATIONS

The remedial action selected for implementation at the Rose Hill Regional Landfill Superfund Site is consistent with CERCLA and the NCP. The Selected Remedy is protective of human health and the environment, attains ARARs and is cost effective. The Selected Remedy partially satisfies the statutory preference for treatment which permanently and significantly reduces the mobility, toxicity or volume of hazardous substances as a principal element and utilizes permanent solutions and alternative treatment technologies to the maximum extent practicable. The remedy uses treatment to address landfill gas emissions and includes excavation of the Bulky Waste Area to reduce mobility of hazardous substances. Consistent with EPA's presumptive remedy for municipal landfills, capping of the consolidated Bulky and Solid Waste Areas was selected given the volume of material and the cost to treat such volume.

Because this remedy will result in hazardous substances remaining on-site above levels that allow for unlimited use and unrestricted exposure, a review will be conducted within five years after initiation of remedial action to ensure that the remedy continues to provide adequate protection of human health and the environment.

ROD DATA CERTIFICATION CHECKLIST

See attached ROD data certification checklist.

AUTHORIZING SIGNATURE

12/20/99
Date

Patricia L. Meaney, Director
Office of Site Remediation and Restoration
EPA - New England

ROSE HILL REGIONAL LANDFILL
SUPERFUND SITE ROD DATA CERTIFICATION CHECKLIST

The following information is included in the Decision Summary section of this Record of Decision. Additional information can be found in the Administrative Record file of this Site.

- Chemicals of concern and their respective concentrations.
- Baseline risk represented by the chemicals of concern.
- Cleanup levels established for chemicals of concern and the basis for these levels.*
- How source materials constituting principal threats are addressed.
- Current and reasonably anticipated future land use assumptions and current and potential future beneficial uses of ground water used in the baseline risk assessment and ROD.
- Potential land and ground-water use that will be available at the site as a result of the Selected Remedy.
- Estimated capital, annual operation and maintenance (O&M), and total present worth costs, discount rate, and the number of years over which the remedy cost estimates are projected.
- Key factor(s) that led to selecting the remedy (i.e., describe how the Selected Remedy provides the best balance of tradeoffs with respect to the balancing and modifying criteria, highlighting criteria key to the decision).

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*NOTE: The selected remedy is a source control remedy which is intended to prevent or minimize the continued release of hazardous substances, pollutants or contaminants to the environment. This decision is also the first operable unit remedy of a phased clean up approach. As such, no cleanup levels are established under this remedy; instead the remedy will meet the performance standards set out in the ROD. The first operable unit remedy will meet all ARARs including those for Site air emissions, landfill closure, and process water discharge or reinjection. Management of the migration of contaminants from the Site will be addressed in a future decision document, based upon data obtained from monitoring conducted under the first operable unit, and any additional studies that are deemed necessary to further assess Site impacts, characterize the extent of contamination, and to assess the need to develop and evaluate alternatives for future actions.

RECORD OF DECISION
First Operable Unit--Source Control

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I. SITE NAME, LOCATION AND DESCRIPTION

The Rose Hill Regional Landfill Superfund Site (the Site) is located within the town of South Kingstown, Rhode Island, in the village of Peace Dale (Figure 1) within Washington County. It lies about 5 miles inland from Narragansett Bay and 2 miles north of Wakefield, Rhode Island. The Site is bordered by Rose Hill Road to the west, the Saugatucket River to the east, and residential private property to the north and south. Remedial response activities including this Remedial Investigation and Feasibility Study were conducted under a United States Environmental Protection Agency (EPA) lead with the State of Rhode Island Department of Environmental Management (RIDEM) remaining active throughout as the support agency.

The Site is located in an abandoned sand and gravel quarry and encompasses approximately 70 acres. As shown in Figure 1, the Site consists of three separate and inactive disposal areas or landfills, referred to herein as the Solid Waste Area (SWA), the Bulky Waste Area (BWA), and the Sewage Sludge Area (SSA). An active transfer station, south of the disposal areas, is also located on the Site (Figure 2).

Two primary surface water bodies flow through the Site: Saugatucket River and Mitchell Brook. An unnamed brook, west of the Site, flows into the Saugatucket River and an unnamed tributary, in the northern portion of the Site, flows into Mitchell Brook. The Saugatucket River is classified by the State of Rhode Island as a Class B water body that is suitable for fishing and swimming. Wetland and flood plain habitats are also found adjacent to the disposal areas and are subject to runoff and contamination from the disposal areas. An open excavated area approximately 400 feet north of the disposal areas is currently used for target and skeet shooting. Approximately 200 feet west of the disposal areas, sand and gravel operators excavate sand, gravel and loam for resale to the public.

Groundwater is used within a 3-mile radius of the Site for the following purposes:

- Private residential supplies (no alternate supply available)
- Municipal public water supply

Residents in South Kingstown obtain water from both public and private wells. Private wells within a 3-mile radius of the Site consist of overburden or bedrock wells. Three supply wells for the University of Rhode Island are located 2.7 miles northwest of the Site. Two municipal supply wells for the Kingston District are located 2.9 miles northwest of the Site. The University and the District utilize each other's systems as water supply back-up.

II SITE HISTORY AND ENFORCEMENT ACTIVITIES

A. Land Use

Prior to 1941, the Site was used for agriculture. Sand and gravel excavation operations were conducted at the Site from at least 1948 through 1963. The Rose Hill Site began operation as a landfill in 1967 in the area previously used for sand and gravel excavation. The landfill was operated by the Town of South Kingstown under a state permit from RIDEM which was renewable annually. For approximately 16 years, it received domestic and industrial wastes from residents and industries in South Kingstown and Narragansett. In October 1983, the landfill reached its state-permitted maximum capacity and active landfilling operations ceased. For the past fifty years, the Site owner has conducted organized small game hunts, the boarding, breeding, training, and showing of hunting dogs, skeet and target shooting, and stocking and periodic release of small game birds throughout the Site.

Facility Operations and Waste Disposal Practices. Table 1 provides a chronology of activities affecting the landfill operations.

Landfills in the three disposal areas (the Solid Waste, Bulky Waste, and Sewage Sludge Areas), began operations in 1967, 1978, and 1977, respectively. The Solid Waste Area landfill was closed in 1982 and the Bulky Waste and Sewage Sludge Area landfills were closed in 1983. During 1983, a transfer station for municipal refuse was located south of the Bulky Waste Area. The transfer station is currently active. At the station, refuse is unloaded from collection trucks and transferred to vehicles that transport it off site to the Johnston landfill. Figure 1 shows the three disposal areas and the transfer station at the Site.

Waste handling procedures for the Rose Hill Regional Landfill were set by state regulations and town ordinance. The waste handling practices conducted at the landfill consisted of the disposal of municipal refuse and industrial refuse including the disposal of industrial wastes. Through its investigation, EPA has acquired some information regarding the disposal and approximate location of these industrial wastes but the exact quantity and location(s) of hazardous substances disposed of on the Site throughout the landfill's operation are predominantly unknown. Information regarding the total volume of solid waste placed in the landfill is available through studies conducted for the Town of South Kingstown by C.E. Maguire.

In 1967, when activity at the landfill officially commenced, a court order prohibited the disposal of combustibles at Rose Hill. In 1978, the order was amended to allow the disposal of combustibles in the Bulky Waste Area. In 1979, the State of Rhode Island ordered cities and towns to establish facilities for the collection of waste oil. It is reported that a waste oil collection facility at the Rose Hill Site was established during this time.

A known waste handling problem concerns the disposal of liquid waste from the Peacedale Processing Company, specifically a urethane adhesive. A letter dated January 8, 1970, transmitted from an engineer of the State Division of Solid Waste Management to the South Kingstown Director of Public Works, put into writing an agreement on the disposal method for liquid waste from the Peacedale Processing Company. The two authorities came to an understanding that the drummed waste would be disposed of daily by dumping it onto other wastes that had been deposited each day. The purpose of this was to take advantage of the absorptive characteristics of the waste materials as the urethane adhesive was disposed.

A year later, on March 16, 1971, correspondence sent from the same state office notified the South Kingstown Town Manager that liquid waste from Peacedale Processing was being improperly disposed of at the Rose Hill Solid Waste landfill. The communication reiterated that the liquid waste should be spread over the surface of the landfill to allow it to be absorbed by the fill, if acceptance of such waste were to continue.

In 1979, a resident observed and reported to RIDEM the dumping of a number of barrels, with the lids intact, on the Solid Waste landfill slope within a few feet of Rose Hill Road. The truck transporting these drums on this occasion was reported to be labeled "Peacedale Processing." The resident further reported at least one barrel was labeled "slop glue." The drums were buried intact with the exception of one. One of these barrels was also observed to be at least part liquid. RIDEM investigated this report and found a drum labeled "DALTOSLEX 535" and "DRANO 21." Daltoslex is a polyurethane fabric coating dissolved in trichloroethylene (TCE), dimethyl formamide (*N,N*-DMF), and cellosolve solvent. Cellosolve is the trademark for mono- and dialkyl ethers of ethylene glycol and their derivatives (Sax and Lewis 1987). Analysis of samples collected from these drums identified hexane, 2-butanone (MEK), TCE, and toluene as components of the liquid. All of these chemicals are widely used industrial solvents. Dimethyl formamide and cellosolve cannot be detected by the common methods used to analyze for volatile organic compounds.

On December 6, 1979, the State Division of Solid Waste Management wrote to Kenyon Piece Dyeworks (a subsidiary of Peacedale Processing) to confirm an analysis of the waste adhesive procured from the Peacedale plant on November 19, 1979. The analysis revealed that the sample contained trichloroethylene at 29,000 parts per billion (ppb), toluene at 400 ppb, and tetrachloroethylene at 4 ppb. An analysis of the waste itself revealed that it contained trichloroethylene in the amount of 0.35%. Based upon the analyses, the waste adhesive produced at the plant was deemed not hazardous [as a solid], as defined by Rhode Island regulations, and could be disposed of at any licensed solid waste management facility. The State added that the waste adhesive was to be in a solid form when taken to the landfill and exposed to the air for at least a week prior to its disposal. Within the same time frame, Kenyon Piece Dyeworks notified the State that the company had suspended shipment of the above-mentioned waste adhesive to the Rose Hill landfill pending further investigation of its environmental reactivity.

Peacedale Processing notified the United States Environmental Protection Agency (EPA), Region I, in 1981 that the company had disposed of laminating adhesive at the Rose Hill Landfill from 1971 to 1979. Although other volatile organics, inorganics, and phthalate compounds have been detected at the Site study area, little is known about the disposal practices associated with these contaminants.

Landfill Disposal Areas. The Solid Waste Area (SWA) operated from 1967 until 1982. The exact depth of deposited solid waste materials is unknown but estimated during studies conducted for the Town of South Kingstown to be to bedrock in some places. Refuse was also reportedly deposited in areas above, below, and at the water table. Areal photographs of the disposal area compiled June 1991 by EPA's Environmental Monitoring Systems Laboratory indicate that the sand and gravel pit was filled in with refuse material starting in the southern portion and progressing north. By 1988, waste materials were present throughout the pit, and all remnants of the original sand and gravel pit were gone. Several possible leachate seeps (rust-colored staining as evidenced in November 5, 1988 photography) are observed in the northern, eastern and southern portions of the disposal area. The thickness of solid waste deposited throughout the landfill prior to 1977 is unknown. However it was estimated that from 1977 to 1982 between 10 and 14 feet of solid waste were deposited. Upon closure, the SWA was reported to have been covered with 0.5 to 2 feet of sandy soil and subsoil. Recent information indicates that only a portion of this area may have been properly covered. Natural vegetation is observed throughout most of this Area; however some spotty, less vegetated sites and occasional exposed debris is apparent where lesser amounts of cover materials were used or subsequently were eroded.

The Sewage Sludge Area (SSA) is located in the northeast section of the Site, between Mitchell Brook and the Saugatucket River. This area operated from 1977 to 1983. Its predominant use was to receive sludge from the South Kingstown wastewater treatment plant. The sludge was deposited in trenches. Aerial photographs taken in 1981 show that the northern section of a large north-to-south-orientated trench, running the entire length of this area, as well as two smaller trenches in the northern section, already contained sludge material. Three unfilled trenches were also visible at that time. The depth of each excavation and the number of trenches are unknown. Reported problems with the high moisture content of the sludge prompted the Town of South Kingstown to initiate the hauling of the sludge to the Johnston landfill. Vegetative cover in this area is less prevalent here than in the Solid Waste Area. In a letter dated July 15, 1993 from RIDEM, Division of Water Resources to the Utilities Director of the Town of South Kingstown, the Department writes: " This Department is thus in a position to confirm that this site has been properly closed, poses no threat to public health as long as the area is not excavated...", and "We [the Department] also take this opportunity to close Order of Approval No. 490 issued for the sludge disposal area."

The Bulky Waste Area (BWA), understood by reference and inference from historic Town records to have been used primarily for the disposal of large "bulky" materials such as appliances, tree stumps, and other debris, is an 11-acre area located east of the SWA and southwest of the

SSA (Figure 1). This area is approximately 200 feet east of Mitchell Brook and 250 feet west of the Saugatucket River. Disposal of materials in this Area began in 1978. Solid waste was also reportedly disposed of in the period between closure of the Solid Waste Area and construction of the transfer station (May 1982 through October 1983). Recent investigative information presented to EPA by the Town of South Kingstown in 1999 offers additional evidence that the BWA is comprised of a far greater amount of municipal solid waste than had been previously reported (see the April 1999 GZA report, in Section 11.10 of Administrative Record). Vegetation, primarily grasses overlying natural fill materials, provides a natural cover for this area.

Property Ownership. Edward L. Frisella, Sr. (deceased) and Pearl F. Frisella are owners of record of the property within which the landfill facility is located. The gravel quarry area, located adjacent to and north of the landfill, is owned by the Estate of Edward L. Frisella, Sr. In 1967, the Town of South Kingstown entered into a lease with Mr. Frisella for the operation of a Solid Waste landfill. After the establishment of the landfill, in February 1973, the Town of Narragansett entered into an agreement with the Town of South Kingstown for joint use and operation of the landfill. In 1977, Edward L. Frisella, Sr., and the Town of South Kingstown reached an agreement upon the continued use of the property as a landfill facility. This amendment to the lease provided additional land for expansion of the landfill facility (i.e., the Sewage Sludge and Bulky Waste Areas). In 1982, the Town of South Kingstown purchased 15.03 acres from Mr. Frisella for the location of the town's transfer station.

B. Response Activity

Several supporting studies have been conducted from 1975 through1994 at the Rose Hill Site prior to and during the Remedial Investigation and Feasibility Study (RI/FS). These studies have generated reports and maps concerning the Rose Hill Landfill Site. The studies are documented in the Administrative Record Index (Appendix E of this document) and many are summarized and/or referenced in either or both of the Remedial Investigation (May, 1994) and Feasibility Study (November, 1998) Reports.

Preliminary Assessment/Site Inspection. The Preliminary Assessment Report for the Rose Hill Regional Landfill Site was completed in January, 1983 followed by a Site Inspection Report completed in September, 1985. The Site was proposed for inclusion on the National Priority List (NPL) on June 24, 1988. Upon review of the Site Investigation and comments received from the proposed listing, EPA chose to conduct an Expanded Site Investigation to further characterize the Site in anticipation of final NPL listing. This effort consisted of more detailed inspection, sampling and surveying of the Site and a final report was submitted in January 1989. On October 4, 1989, the Site qualified for a final listing on the NPL.

In 1985, the Town of South Kingstown provided a municipal water line extension to adjacent residences located on Rose Hill Road and those dwellings abutting the immediate northern portion of the Site. The municipal water line extends as far north as the Site owner's driveway (across from 349 Rose Hill Road and marked by a terminal hydrant). Hookups to the waterline were voluntary. One resident who initially refused the service was subsequently provided municipal water. By 1989, water service was provided to Broad Rock Road. Generally, residences along Rose Hill Road directly west and south of the Site use municipal water. A number of residences on Saugatucket Road and Broad Rock Road are not connected to municipal water and continue to use private wells, as do residents north of the Site on Rose Hill Road.

Removal Action. The Remedial Investigation (RI) and Feasibility Study (FS), conducted by EPA, began in 1990 with field work commencing in the Spring of 1991. In June 1991, Metcalf and Eddy (M&E), as EPA's remedial response contractor for performance of the RI/FS, installed permanent soil gas sampling wells on the three landfill disposal areas and along the perimeter of the Site. Initial results of sampling from the soil gas wells indicated the presence of explosive levels of combustible gases in the vicinity of residential dwellings abutting the landfill. As a result of M&E's soil gas results, the EPA Remedial Project Manager requested assistance from the EPA Emergency Planning and Response Branch (EPRB) to perform a removal assessment of nearby residential dwellings to ensure that the structures were free of migrating gases. The following paragraphs discuss the removal response actions conducted by EPA and a summary of the resultant conclusions. A complete history of this work, monitoring results, and reports on the removal be found in Section 2 of the Administrative Record under Removal Response.

On November 8, 1991 personnel from the United States Environmental Protection Agency Emergency Planning and Response Branch (EPRB), Waste Management Division (WMD; now known as the Office of Site Remediation and Response (OSRR)), the South Kingstown Fire Department and Technical Assistance Team (TAT) monitored 12 dwellings in proximity to the Solid Waste Area landfill for the presence of combustible gases. The results of this survey indicated that the dwellings were free of detectable concentrations of combustible gases. These results are found in a document entitled: *Methane Gas Investigation for Rose Hill Landfill, South Kingstown, Rhode Island, December 1991,* prepared by TAT.

In December 1991, the Agency for Toxic Substances and Disease Registry (ATSDR) issued a health evaluation based on analytical data generated by M&E as well as the residential survey performed in November 1991. At that time, ATSDR stated "..the data did not indicate any public health concerns, but EPA should continue periodic monitoring of the houses". As a result, EPRB requested that TAT monitor the residential dwellings on a monthly basis for the next four months. From December 1991 through March 1992, TAT monitored eight residential basements for combustible gases in ambient air using an organic vapor analyzer (OVA), a combustible gas indicator (CGI), and a photoionization detector (PID). During this time, OVA readings above background levels were observed in several residential basements, with the residential basement at 220 Rose Hill Road containing concentrations significantly above the background level (240-1,000 units). PID readings in this residential basement were not above the background readings, indicating that the gas was methane, a common landfill by-product, which is detected by the OVA but not the PID.

In July 1992, ATSDR issued another health consultation based on the monthly monitoring data and a sample collected from a soil gas well located along the foundation of 220 Rose Hill Road. Methane was detected at 18,000 parts per million (ppm) at this soil gas well.

ATSDR recommended that "a methane monitor/alarm be installed in the residence which had the 37% lower explosive level (LEL) at its external foundation". ATSDR recommended that periodic monitoring be performed on other residences.

In July 1992, EPA requested that TAT begin a biweekly monitoring program designed to monitor residential basements and the soil gas wells (installed by M&E) using a CGI, an OVA equipped with a charcoal filter (to eliminate all organic compounds except methane, ethane, and propane), and a PID (to verify that the gases detected with the OVA were methane). From July through September 1992, elevated levels of gases were detected in soil gas wells, but no significant concentration of gases were detected in any of the residential basements, including 220 Rose Hill Road. A summary of the residential basement sampling and the soil gas well sampling performed by TAT from December 1991 through September 1992 can be found in the report entitled: *Air Monitoring Data Tables, Rose Hill Regional Landfill Site, South Kingstown, Rhode Island, December 1991 - September 1992,* prepared by TAT.

On September 2,1992, EPA and TAT collected soil gas samples in Summa canisters at three soil gas wells and submitted the samples to the EPA New England Regional Laboratory (NERL) for VOC analyses. The results of the Summa samples indicated the presence of vinyl chloride in soil gas well LFGR-8 at a concentration of 4,000 ppm. The remaining two Summa samples contained other VOCs at low levels but no vinyl chloride. The presence of vinyl chloride in soil gas well LFGR-8 was verified by TAT on September 16, 1992, using a vinyl chloride Drager Chemical Detector Tube.

In October 1992, ATSDR issued another health consultation based on the September 2, 1992 Summa canister sampling results. ATSDR stated, "The presence of high levels of vinyl chloride in soil gas (4000 ppm) would justify additional characterization to determine the extent (if any) of the contaminant migration from the landfill. Additional air monitoring should include ambient air, both from the landfill property and the adjacent residential area."

On October 14, 1992, EPA Deputy Regional Administrator Paul Keough signed an Action Memorandum for Regional Administrator Julie Belaga, authorizing $1,920,000 to mitigate the threat to public health or to the environment resulting from the actual or potential exposure to nearby human populations from the migration of the landfill gases.

On October 19-20, 1992, an air and soil gas sampling survey was conducted by personnel from EPRB, the EPA Environmental Response Team (ERT), the Roy F. Weston, Inc. Response Engineering and Analytical Contract (REAC) Team and TAT. Based on the results obtained from this survey, REAC prepared two reports. The first report, entitled: *Final Emission Modeling*

Report, Rose Hill Regional Landfill, South Kingstown, Rhode Island, December 1992, estimated that the landfill would generate 800 megagrams per year (Mg/year) of methane for the next few years, and also generate 7 Mg/year of nonmethane organic compounds (NMOC). The second REAC report, entitled: *Final Air Quality Modeling Report, Rose Hill Regional Landfill, South Kingstown, Rhode Island, December 1992,* estimated that the residences around the landfill would be exposed to an average 10.7 parts per billion, volume to volume (ppb/v) vinyl chloride. Since these were models, actual data were needed to verify the estimates. Therefore two additional surveys were scheduled for the Site by EPA. In January 1993, EPRB issued a work assignment to M&E to prepare a report evaluating options for an expedited response action to mitigate the subsurface migration of landfill gases toward the residential dwellings.

The first survey was conducted by EPRB and TAT from February through March 1993, when the Site was covered by snow, and the subsurface migration of landfill gases was thought to be at the annual maximum. This survey found that only one residential dwelling (220 Rose Hill Road) had significant concentrations of methane (up to 2500 ppm) and vinyl chloride (up to 22 ppb/v). Based on the vinyl chloride result, ATSDR stated that an increased cancer risk may exist if the exposure of these levels of vinyl chloride was greater than 1.45 years. Based on the maximum vinyl chloride concentration (1.78 ppb/v) found in the other residential basements sampled and the outside ambient air, ATSDR stated that no adverse health affects were expected to occur (for the same interval of time). A summary of the results of the survey can be found in the report entitled: *Rose Hill Regional Landfill Site, Indoor Residential Air Survey Results, South Kingstown, Rhode Island, February 1993 - March 1993,* prepared by TAT.

The second survey was conducted by ERT and REAC from May 24-28, 1993, when the surface of the landfill was permeable, and the vertical migration of the gases through the surface of the landfill was thought to be at the annual maximum. Based on the results from this survey, REAC predicted the residences around the landfill would be exposed to an average 0.008 ppb/v vinyl chloride. A summary of the results can be found in the reports entitled: *Observed Ambient Air Impact Report, Rose Hill Regional Landfill, South Kingstown, Rhode Island, July 1993* and *Air Quality Modeling Final Report, Rose Hill Regional Landfill, South Kingstown, Rhode Island, August 1993,* both prepared by REAC.

The report recommended the installation of a landfill gas mitigation system consisting of a series of perimeter gas extraction wells, a gas collection system and an enclosed flare to burn the off-gases. M&E estimated the capital cost of this action at $3,770,000 and a yearly Operation and Maintenance cost of $350,000. Based upon sampling results and cost benefit analyses, an interim response action consisting of landfill gas sensors equipped with alarms for three residences and a landfill gas ventilation system for one dwelling was recommended by EPRB. A unilateral order was issued to the Town of South Kingstown in March 1993 with the above mentioned requirements (see Enforcement History below). A week later, EPRB approved the Town's Work Plan in response to the issued order requiring gas sensors, alarms, and one ventilation system to be installed at the residents' properties. By May 1993, the Town placed gas sensors and alarms at two residences and initiated discussions with the property owner of 220 Rose Hill Road about installing a ventilation system or, alternatively, razing the dwelling. The March 1993 M&E report was used extensively as support documentation for the Feasibility Study and the remedial (long-term) response action.

On April 12, 1993, ATSDR issued a health evaluation for the samples collected in February and March 1993. ATSDR concluded that the exposure to a concentration of 21 ppb vinyl chloride at 220 Rose Hill Road may result in an increased cancer risk if the exposure were to exceed 1.45 years. ATSDR recommended that actions be taken at this residential property to prevent long term exposure. ATSDR reviewed the vinyl chloride data for the other residential dwellings and the ambient air sample results collected in February and March of the same year and concluded that "no significant risk is expected as a result of exposure to this level of vinyl chloride (a concentration range reported from non-detect to 0.99 ppb at the other residential dwellings) within the time frame that remedial action is expected to be in place (approximately 10 years)".

In June 1993, the Town of South Kingstown by agreement with the property owner and under order by EPA razed the building located at 220 Rose Hill Road and prohibited any future housing on the property.

Shortly after ERT and REAC submitted their July 1993 report entitled *Observed Ambient Air Impact Report* and the August 1993 *Air Quality Modeling Final Report* for samples gathered from May 24-28, 1993 from the residences and at the landfill, ATSDR prepared a health consult for EPA which concluded: "The maximum detected vinyl chloride [and benzene] concentration (1.6 ppb [23.4 ppb for benzene]) is below levels shown to produce adverse, non-carcinogenic health effects in animals or humans. However, long term exposure to this concentration of vinyl chloride [and benzene] in air could cause an increased risk of cancer". The health consult also contained the following recommendation: "Implement appropriate remedial actions to reduce risks associated with chronic exposure to benzene and vinyl chloride in air."

The final reports also indicated a possible "upwind" (westerly) source for these contaminants, in addition to the Rose Hill Landfill. Based on subsequent peer review of the report and additional RI data, this conclusion is thought to be erroneous. No substantiated documentation on the use, storage or disposal of any hazardous substances, including but not limited to, benzene or vinyl chloride, are known to exist with respect to the properties along Rose Hill Road and adjacent to the landfill. The report indicated that the wind velocity and direction was quite variable and at times calm. The PAL dispersion model used for this study cannot readily predict concentrations under these conditions. Therefore, the model may seriously under-predict the concentration for vinyl chloride when compared to concentrations as measured at the residential receptors. This suggests that the model results have substantial uncertainty for vinyl chloride (and for other compounds). The possible reasons for under-predicting contaminant concentrations are: 1) emission is underestimated, 2) dispersion is overestimated, and 3) that the conceptual model may be inadequate. For example, emissions may be underestimated if the flux chambers do not represent the actual flux of landfill gas across the entire landfill surface or if laboratory recovery of vinyl chloride was low; dispersion may be overestimated if the PAL model does not adequately account for near-calm conditions; the conceptual model may be inadequate if landfill gas migrates below the ground surface to the vicinity of residential receptors. Benzene is a fairly ubiquitous contaminant and, although found to be present at the landfill, was not found in substantial concentrations in samples of landfill gas. It may be reasonable therefore to suspect that off-site sources may contribute to the recorded measurements of benzene. However, vinyl chloride was found in substantial concentrations in landfill gas. This compound is not ubiquitous and is known to be a substantial degradation byproduct of chlorinated compounds found in quantity at the landfill. Since both ambient measurement results and modeled concentrations are subject to significant uncertainty, it is entirely speculative to attribute vinyl chloride at receptor locations adjacent to the Rose Hill Landfill to unknown off-site sources. The continued remedial work, including but not limited to the RI, FS, and the human health risk assessment, also took these factors into account and more advanced modeling concepts were sought in support of the continued remedial response.

In early 1994, the Town installed a bentonite clay dam around the town water line feeding the resident at 278 Rose Hill Road to prevent landfill gases from entering the residence. The Town also moved the sensor from against the outside basement wall to inside the basement to record methane concentrations inside the dwelling. The Town continues to maintain the equipment and submit data reports to EPA.

Preliminary Natural Resource Survey. On June 24 1994, the National Oceanic and Atmospheric Administration (NOAA) submitted a Preliminary Natural Resource Survey (PNRS) for the Site. The findings presented in the PNRS are based upon results documented in the EPA RI report and in a preliminary screening study entitled *An Evaluation of Saugatucket Pond Sediment, South Kingstown, Rhode Island, Final Report* (NOAA, 1994). These latter reports can be found in their entirety in Section 16 of the Administrative Record.

The findings of the PNRS indicate that the Rose Hill Regional Landfill Site is located in the Saugatucket River basin, adjacent to the Saugatucket River and Mitchell Brook, a tributary to the river. Fish passage facilities have been installed on the Saugatucket River to allow for upstream migration of anadromous fish species. The river now provides significant spawning and nursery habitat for alewife and blueback herring. Contamination from the Rose Hill Landfill may pose a threat to natural resources, including NOAA trust resources utilizing Mitchell Brook, the Saugatucket River, and Saugatucket Pond. The primary pathways of contaminant migration from the Site are groundwater discharge and surface water runoff. Iron and several trace elements were detected at elevated concentrations in surface water and sediment during the RI. The leachate seeps located on the perimeter of both the Bulky Waste and Solid Waste Areas appear to be a source of contamination to surface water bodies. A floc sample collected from Mitchell Brook contained substantial amounts of iron. In addition, iron was present at high concentrations in sediment collected as far downstream as Saugatucket Pond. Flocculent material that accumulates near the Site may be a source of iron in sediments of the pond. Results suggest that sediment and floc transported from the vicinity of the Site contains concentrations of iron and possibly other trace element contaminants that may adversely effect blueback herring and alewife inhabiting Saugatucket Pond during sensitive life stages. While the results of the PNRS and sediment study were not unequivocal, they provided sufficient evidence to justify further study and analysis of the relationship between Site releases and adverse biological responses downstream in Saugatucket Pond.

C. Enforcement History

In April and June of 1989, EPA sent general notice letters to eight Potentially Responsible Parties (PRPs). EPA met with the PRPs in June 1989 and in June 1990, EPA sent out special notice letters to the PRPs to undertake an RI/FS. After failed attempts at negotiations, EPA requested and received funding from the Superfund trust fund to begin the RI/FS at Rose Hill.

Actual field work for the Remedial Investigation (RI) began in the Spring of 1991. Shortly after the initiation of the RI, it became apparent that the Site owner's continued use of the property (including, hunting, sport and target shooting, dog training, and other related activities) presented an unreasonable and unacceptable risk to EPA and its contractors and placed operational restrictions upon EPA in conducting the necessary field activities. On August 21, 1991, EPA issued an Administrative Order for Property Access to the property owner. An amendment to the Administrative Order for Property Access was issued on March 27, 1992 which allowed the limited use of a ten acre parcel for his business-related activities.

In March 1989, the Agency received notice of a bankruptcy proceeding and filed a proof of claim seeking reimbursement of response costs against Coated Sales and its wholly-owned subsidiary, Kenyon Industries, Inc. The Coated Sales bankruptcy proceeding involved six related corporate entities. EPA had claims against two of them, Coated Sales, Inc. ("CSI"), and Kenyon Industries, Inc. ("Kenyon"), a Rhode Island corporation and subsidiary of CSI. The bankruptcy proceeding presented EPA with its only opportunity to resolve its claims for response costs under CERCLA against CSI and Kenyon, corporate affiliates of Peacedale Processing Company, Inc., a known hazardous waste generator at the Site. In June 1994, the case was settled with EPA recovering a portion of its response costs.

On March 26, 1993, as an enforcement component to the Removal Action, EPA issued a Unilateral Administrative Order (RCRA Docket 1-93-1055) (the Order), directing the Towns of Narragansett and South Kingstown to install methane gas sensors/alarms outside the foundations and in the basements of 278 Rose Hill Road and 349 Rose Hill Road. The Order also directed the Towns to install a methane gas ventilation system and a gas sensor/alarm in the basement of 220 Rose Hill Road. As an alternative to the second directive, the Towns relocated the residents of 220 Rose Hill Road and razed the building on June 4, 1993. The alarms at 278 and 349 Rose Hill Road were installed on May 18, 1993. A summary of the alarm installation activities can be found in the report entitled: *Completion of Work Report for Environmental Protection Agency, Administrative Order 1-93-1055, February 9, 1994,* prepared by Geological Field Services (the Town of South Kingstown's consultant). The Town is required to perform maintenance and monitoring activities and report a summary of the collected data to EPA annually.

Further information regarding the above described enforcement activities be found in Section 10 of the Administrative Record.

III. COMMUNITY PARTICIPATION

Throughout the Site's history, community concern and involvement has been moderate. EPA has kept the community and other interested parties apprized of the Site activities through informational meetings, fact sheets, press releases and public meetings.

In June 1991, EPA released a community relations plan which outlined a program to address community concerns and keep citizens informed about and involved in activities during remedial activities. On June 18, 1991, EPA held an informational meeting in South Kingstown, RI to describe the plans for the Remedial Investigation and Feasibility Study. On June 23, 1994, EPA held an open house in South Kingstown, RI to discuss the results of the Remedial Investigation.

During the removal activities, meetings were held with the residents of Rose Hill Road on January 20 and April 29, 1993 to inform the residents of monitoring results, ongoing work and proposed actions.

EPA published a notice and brief analysis of the FS and Proposed Plan in the Providence Journal on January 29, 1999 and made the plan available to the public at South Kingstown Public Library. On February 1, 1999, EPA made the Administrative Record available for public review at EPA's offices in Boston and at South Kingstown Public Library.

On February 2, 1999, EPA held an informational meeting to discuss the results of the Remedial Investigation and the cleanup alternatives presented in the Feasibility Study and to present the Agency's Proposed Plan. Also during this meeting, the Agency answered questions from the public. A joint letter from the Towns of South Kingstown and Narragansett was received on January 27, 1999 which contained a formal request to extend the 30 day public comment period by sixty days. In response to this request, the Agency held a 90-day public comment period from February 3 to May 3, 1999 to accept public comment on the alternatives presented in the Feasibility Study and the Proposed Plan and on any other documents previously released to the public. On February 18, 1999, the Agency held a public hearing to discuss the Proposed Plan and to accept any oral comments. A transcript of the hearing, the comments, and the Agency's response to comments are included in Appendix C (Responsiveness Summary) of this ROD.

Throughout the time in which the RI/FS was conducted, EPA solicited views from the Site owner, neighboring property owners, the State, the Town, and local citizen groups on the current and reasonably anticipated future land uses, and current and potential future groundwater use and value within the Site boundary and in adjacent areas. Section VI of this ROD contains a brief summary of that information.

IV. SCOPE AND ROLE OF THE FIRST OPERABLE UNIT RESPONSE ACTION

The Feasibility Study (FS) analyzed source control and management of migration alternatives for the Site. Upon extensive review and consideration of new information and comments presented during the public comment, EPA believes that additional data is needed to properly assess and evaluate management of migration options for groundwater and its impact on surface water after the source control remedy is implemented. Instituting a well designed source control remedy at the present time will minimize the migration of contaminants to groundwater. Accordingly, a more cost effective and potentially less extensive management of migration remedy can be realized through a phased approach.

The selected remedy is the first operable unit of a phased approach to remediate the environmental contamination caused by the Site. The first operable unit is a source control remedy which is intended to prevent or minimize the continued release of hazardous substances, pollutants or contaminants to the environment. Source control alternatives rely on the prevention of exposure for the protection of human health and the environment.

The first operable unit will control the sources of contamination at the Site by limiting percolation and infiltration from precipitation through waste materials thereby controlling an otherwise continued release of hazardous substances to the air and ground water. The first operable unit remedy will minimize the further migration of hazardous substances, pollutants and contaminants to groundwater and surface water. Future management of the migration of contaminants to surface and ground water will be based on data obtained from the first operable unit monitoring and any additional studies that are deemed necessary in order to further assess Site impacts, characterize the extent of contamination, and assess the need to develop and evaluate alternatives for future actions, should it be found necessary to do so.

The first operable unit remedy consists of the following components: Consolidate the Bulky Waste Area landfill onto the Solid Waste Area landfill; collect and manage leachate and waters collected from runoff and de-watering operations during the excavation and consolidation of the Bulky Waste Area; apply a protective cover (hazardous waste cap) to the Solid Waste Area landfill; assess, collect and treat landfill gases via an enclosed flare; inspect and monitor the integrity and performance of the cap over time; monitor groundwater, surface water, leachate emergence, and landfill gas emissions over the duration of the remedial action; implement deed restrictions (in form of easements and covenants) on groundwater and land use and prevent access onto the portions of the Site where remediation activities warrant this restriction; provide data to assess the need for taking any further response actions after the cap is in place and functional; operation and maintenance of the remedy; and plan for and conduct statutory five-year reviews to ensure protectiveness. Site monitoring will furnish data to assess the effectiveness of the source control remedy and assist the State with TMDL predictions for Site-related contaminant concentrations affecting local water bodies. The Sewage Sludge Area meets minimal State requirements for sewage sludge landfill closure, and poses no significant health threat as closed. The source control remedy includes continued monitoring of this area.

The exposure to and inhalation of landfill gas and the exposure to and ingestion of contaminated groundwater are principle threats to human health posed by the Site. Leachate production poses an ecological threat to the Saugatucket River and Mitchell Brook. Consolidating and capping the landfill wastes coupled with controlling landfill gas emissions will minimize these threats by containing and treating these contaminants on-site. Once the sources are consolidated, the role of the landfill cap is to 1) effectively contain the source, 2) contain and control landfill gas emissions, 3) minimize any further migration of contaminants from the source to the groundwater, and 4) minimize the migration of the contaminated groundwater plume. Ecological risks associated with leachates reaching and impacting nearby surface water bodies are also substantially reduced through 1) removing one source in immediate proximity to the Saugatucket River, 2) consolidating the source areas to one location away from the Saugatucket River, and 3) effectively containing the combined source area, using a multi-layer hazardous waste cap. Long-term environmental monitoring coupled with deed restrictions to prevent the use of, or hydraulic alteration of, groundwater throughout the Site will ensure that the selected remedy remains protective of human health and the environment. Further assessment of the groundwater and surface water impacts as a component of the long-term environmental monitoring will be conducted after the cap is in place and functional to ensure remedy integrity and protectiveness and to support any future remedial actions that may be necessary in response to those risks posed by the Site.

V. SUMMARY OF SITE CHARACTERISTICS

Sections 1.2, 1.3 and 1.4 of the Feasibility Study (FS) contain background information including an overview of the Remedial Investigation (RI). The significant findings of the RI are summarized below. The RI/FS support documentation can be found in the Administrative Record under Section 3.0 and 4.0, respectively.

The Site study area is situated in the southwest corner of Rhode Island about five miles inland from Narragansett Bay, approximately two miles north of Wakefield, Rhode Island and located within Peace Dale; a small village of the Town of South Kingstown. The topography of the area is typical for coastal lowlands of the northeastern United States, generally flat with gently rolling hills. Elevations range from 50 to 260 feet above mean sea level with slopes of generally less than three percent.

Several geologic features that impact the movement of groundwater across the Site were identified. The behavior of groundwater in the bedrock was found to be influenced by bedrock topography, with recharge and discharge occurring at bedrock high and low areas, respectively. The predominant flow of groundwater in bedrock is to the southeast along regional fractures. Weathered and fractured bedrock (Scituate Gneiss, USGS 1956) south and west of the Solid Waste Area appears to facilitate interconnection of the overburden and bedrock flow systems.

The three major constituents of the overburden are ablation till, glacial lacustrine deposits, and glacial outwash sediments. The till and glacial outwash permit unconfined groundwater flow in a south-southeast direction. Although the groundwater flow is predominantly to the south-southeast, mounding of groundwater in the northwest corner of the Solid Waste Area may facilitate radial flow to the north, east, and west. Lacustrine deposits, encountered in the south-southeastern portion of the Site, act as a confining layer between the till and outwash. A combination of the rise in the surface elevation of the bedrock and the presence of thick lacustrine deposits along the Saugatucket River plays a significant role in the increased horizontal gradient and strong upward gradients observed south of the Bulky Waste Area.

Due to the composition and condition of existing cover materials, infiltration of precipitation through these materials is expected to be high. Groundwater interactions with the Saugatucket River and Mitchell Brook most likely play an important role in the transport of contaminants. The Saugatucket River was observed to gain water from the shallow and deep overburden and the bedrock flow systems along the western side of the river. Mitchell Brook was observed to lose water to groundwater in its upper reaches and gain groundwater in its lower reaches.

Significant ecological habitats within the Site include the Saugatucket River and Mitchell Brook, their associated tributaries and forested wetlands, and the adjacent forested and old field upland habitats. Rare plant species known to occur within the Site include a species of state interest, tickseed sunflower *(Bidens coronata)*, and a species of state concern, bloodroot *(Sanguinaria canadensis)*. A probable sighting of an avian species of state concern, red-bellied woodpecker *(Melanerpes carolinus)*, also occurred within the Site. Two avian species of state interest, glossy ibis *(Plegadis falcinellus)* and great egret *(Casmerodius albus)*, were also observed within the Site. However, the state designation applies only to breeding sites for these two species, and suitable breeding habitat does not exist within the Site, except possibly along the Saugatucket River.

As indicated by a single, reconnaissance-level survey, the Site is utilized by a variety of terrestrial species. Avian species observed on the Site were generally typical of those expected based upon geographical location, habitat present, and surrounding land uses. The extensive running of dogs and hunting on the Site have influenced the use of the Site by mammalian species. Reptiles and amphibians utilizing the Site are likely to be confined largely to terrestrial species, as Mitchell Brook does not appear to support large numbers of these organisms or other prey species, such as fish. However, the Saugatucket River likely supports a more diverse assemblage of wildlife and aquatic species.

The macroinvertebrate species composition in the sediments of the Saugatucket River appears to be affected by the disposal areas. The species composition (in terms of the relative abundance of dominant organisms) adjacent to the disposal areas appears to be different from the species composition in upstream and downstream locations. The area adjacent to the Bulky Waste Area has the most contaminated sediments and pollution-tolerant taxa did occur in relatively high numbers in the sediments compared to the taxa in sediments in upstream and downstream locations.

Organisms in the water column of the Saugatucket River also appear to be more directly influenced by the disposal areas and leachate seeps. Total densities of organisms in the water column downstream of the disposal areas and leachate seeps are significantly lower than at upstream locations. The occurrence of pollution-sensitive invertebrate taxa in the water column also decreased from upstream to downstream locations. There also appears to be a scarcity of fish in this section of the river, where resident and migratory fish would be expected to occur.

The benthic macroinvertebrate community in Mitchell Brook does not appear to be as diverse as that of the Saugatucket River. In general, the macroinvertebrates in Mitchell Brook sediments and surface waters showed a pattern of decreasing densities from upstream to downstream locations. Species density and diversity were especially low adjacent to the disposal areas. Additionally, the occurrence of pollution-sensitive species decreased from upstream to downstream locations. In the Brook, as in the Saugatucket River, few fish were observed.

Historical sampling data gathered in support of the Preliminary Assessment and Site Investigation indicated the presence of contaminants in groundwater, landfill leachate, surface water, and sediments within the vicinity of the Site. The contamination information was summarized in the Preliminary Health Assessment written by ATSDR in 1990 and presented as follows:

- Historical contaminant concentrations in ground water collected from on-site wells were variable.

- Surface water quality data from Mitchell Brook collected in 1982 revealed the presence of 1,1,1-trichloroethane (2 ppb), methylene chloride (1 ppb), 1,2-dichloroethylene (11 ppb), 1,1-dichloroethane (1 ppb), and toluene (2 ppb).

- Off-site residential wells have also intermittently revealed the presence of contaminants reportedly attributable to the Site. These contaminants included trans-1,2-dichloroethylene (27 ppb), trichloroethylene (6 ppb), di-n-butyl phthalate (20 ppb), and diethyl phthalate (20 ppb).

- In leachate, primarily from the Solid Waste Landfill, 1,1-dichloroethylene (5 ppb), trans-1,2-dichloroethylene (10 ppb), cis-1,2 dichloroethylene (2,260 ppb), benzene (15 ppb), toluene (385 ppb), ethylbenzene (35 ppb), and m-xylene (50 ppb) were reported.

- Surface water and soil samples collected in November 1987 and March 1988 revealed several volatile and extractable organic compounds; however, sampling and analytical problems precluded further use of this data.

Based upon, and in response to, the preliminary studies, the RI field work was initiated in 1991 and completed in 1994. Chemical data for surface soil, subsurface soil, groundwater, surface water, sediment, leachate, and landfill gas derived from the RI field investigation are presented below. The nature and extent of contamination in the Site study area was evaluated using analytical data generated during the RI field investigation. The results of the field investigation and information on the historical activities associated with the Site study area were used to provide an understanding of contamination and Site condition. A chronology of the RI field investigation activities is found in Table 2. To more effectively present the analytical data for the Site, sampling locations are grouped according to geographical location, disposal area or water body. Table 3 presents, by media, the different groupings used in this section.

A. Soil

Thirteen surface soil samples (SS-01 to SS-13), from 0 to 6 inches in depth, were collected in September/October 1991. In April 1992, 11 additional samples (SS-14 to SS-24) were collected from depths of 0 to 12 inches.

Three background locations (SS-01, SS-02, and SS-14) were selected and sampled. Three samples were located on the Sewage Sludge Area (SS-11, SS-12, and SS-15), three on the Bulky Waste Area (SS-09, SS-10, and SS-24), six on the Solid Waste Area (SS-03, SS-04, SS-05, SS-13, SS-16, and SS-17), and nine in non-disposal areas (SS-06, SS-07, SS-08, SS-18, SS-19, SS-20, SS-21, SS-22, and SS-23). Surface soil sampling locations are shown in Figure 3. Samples were analyzed for the following parameters:

- Volatile organics
- Semivolatile organics
- Pesticides and PCBs
- Metals
- Cyanide
- Total combustible organics (TCO; September 1991 only)
- Grain size (September 1991 only)

In addition, fourteen subsurface soil samples were collected from seven soil borings (two from each boring). Each of the borings was advanced to a depth of 20 feet. One background boring, BH-05, was drilled. Four borings were advanced in the Sewage Sludge Area (BH-01 through 04), one boring was advanced in the Bulky Waste Area (BH-06), and one was advanced in the Solid Waste Area (BH-07). Two samples from each boring were also analyzed for the above listed parameters. The analytes detected in surface soils are presented in Tables 4 and 5. The analytes detected in subsurface soils are presented in Table 6.

Surface Soil Results Summary. The presence of organic compounds in the surface soils were largely related to location (proximity to waste disposal areas). Volatile organics were the most prevalent organic compounds detected, and chlorinated and aromatic compounds and ketones were detected most frequently and in the highest concentrations. Refuse and landfill gas were the primary sources of volatile organics in surface soil. Elevated iron concentrations were found in samples near leachate seeps, and elevated lead was found throughout the Site.

Background Results. Three background samples (SS-01, SS-02, and SS-14) were collected north of the disposal areas. The locations selected were in areas that are upgradient of disposal areas and appear undisturbed by landfill operations. Samples were collected from topsoil materials and did not exhibit any signs of recent disturbance. As a result, the samples collected are considered to be representative of background conditions for surface soil.

Five organic compounds were detected infrequently at concentrations below sample quantitation limits in the background samples. Acetone was detected at 480 µg/kg in SS-14. Two phthalates, diethylphthalate and butylbenzylphthalate, were each detected at SS-02 (31 µg/kg) and SS-01 (41 µg/kg), respectively. Phthalates are widely distributed in residential as well as commercial areas because they are components in many plastics, pesticides, hydraulic oils, and lubricants. Since much of the Site study area has been used for multiple purposes, such as farming and residential use, the detection of phthalates was not unexpected.

Two polycyclic aromatic hydrocarbons (PAHs), fluoranthene (25 µg/kg) and pyrene (29 µg/kg), were also detected in SS-01, which is located approximately 20 feet away from a dirt road, and are most likely attributable to vehicular activities. Four pesticides were found in SS-01 and SS-14 at concentrations ranging from 0.6 to 1.2 µg/kg: 4,4'-DDT, 4,4'-DDE, aldrin, and endrin ketone. This family of chlorinated pesticides has been regularly used for insect control in both residential and agricultural applications from the early 1900s to the 1980s. The concentrations detected are most likely residual pesticides that were applied in the past to areas in or surrounding the Site study area. PCBs were not found in any of the background samples.

With the exception of sodium, major-metal ions (aluminum, iron, calcium, magnesium, and potassium) were detected in the three background samples at concentrations higher than those for other metals. Aluminum ranged from 12,200 to 16,600 mg/kg, iron ranged from 12,300 to 18,100 mg/kg, and basic cations (calcium, magnesium, and potassium) ranged from 213 to

1,360 mg/kg. Sodium was not reported as discussed in section 2.6. Other metals detected in the background samples include barium (15.4 to 37.8 mg/kg) and 12 heavy metals:

arsenic	2.1 to 2.8 mg/kg
chromium	11.2 to 17.5 mg/kg
cobalt	3 to 3.6 mg/kg
copper	3.5 to 5.3 mg/kg
lead	11.1 to 30.1 mg/kg
manganese	82 to 267 mg/kg
mercury	0.17 mg/kg
nickel	4.1 to 5.5 mg/kg
thallium	0.28 mg/kg
vanadium	16 to 25.7 mg/kg
zinc	21 to 30.1 mg/kg

These metals are present in other soil samples in the eastern United States and Rhode Island, with the exception of thallium, which was not analyzed for, and beryllium, which was not detected in the literature samples. Barium, beryllium, chromium, cobalt, copper, lead, manganese, mercury, vanadium, and zinc were also found in background subsurface soil samples collected in the Site study area. Aluminum, lead, and mercury were found at concentrations within the ranges listed for the eastern United States and at concentrations less than those reported in the Rhode Island sample. Lead and beryllium were found at concentrations above those reported for the Rhode Island sample but within the range reported for the eastern United States. Since metals are naturally occurring in soils and can vary within a small area, it was not possible to determine the significance of differences between literature values and concentrations detected in these samples. However, lead concentrations may be elevated throughout the Site study area because of bullets (or pellets, shot) used in the shooting of game birds, skeet shooting, and target practice, in recent years.

Cyanide was not detected in any of the background samples. The organic content of the samples was measured as 6.8 and 7.5% at SS-01 and SS-02, respectively, which indicate low organic content in the soils.

Sewage Sludge Area Results. Surface soil samples were collected at three locations (SS-11, SS-12, and SS-15) in the Sewage Sludge Area. Topsoil/fill material was encountered at thicknesses of 2 to 5 feet (based on boring activities) in several locations in the Sewage Sludge Area. The origin and thickness of fill overlying the Sewage Sludge Area is not entirely known. The fill is reportedly from a combination of off-site sources and sand and gravel excavated from areas north of the disposal areas (Figure 4). There was no evidence of sludge material in any of the surface soil samples. In addition, vegetation was not present in the immediate vicinity of SS-11.

The analytes detected are presented in Tables 4 and 5. Figures 5 and 6 present a summary of the organic compounds detected.

A few organic compounds, including several volatile and semivolatile organics and pesticides, were identified in two of the surface soil samples (SS-11 and SS-12), but were not detected in SS-15 (Tables 4 and 5). PCBs were not detected in any of the samples.

Acetone was detected in SS-11 (23 µg/kg) and SS-12 (14 µg/kg), and 2-butanone (MEK) was detected in SS-12 (4 µg/kg). Diethylphthalate was also detected at a concentration less than sample quantitation limits (29 µg/kg) in SS-12. A similar concentration was found in a background surface soil sample. Tetrachloroethene and pyrene were detected in SS-11 at concentrations below sample quantitation limits (2 µg/kg and 26 µg/kg, respectively). Pyrene was also detected in the background surface soil.

In addition, 4-chloroaniline, dieldrin, and *alpha*-chlordane were detected in SS-11 at 490, 4.5, and 3.7 µg/kg, respectively. The source of these compounds is not clear. The immediate area from which SS-11 was collected is characterized by the absence of vegetation. While there was no physical evidence of sludge material at this location, similar compounds were detected in subsurface media investigated in this area. *alpha*-Chlordane was detected from 2 to 8 feet in BH-01, located in the southern portion of the disposal area, and 4-chloroaniline was also found in groundwater from MW-II, in the central portion of the Sewage Sludge Area. Both the boring and well are in contact with sludge material.

If present in buried sludge, limited partitioning of pesticides from the sludge material upwards into the cover material would be expected because of strong adsorption and low volatility characteristics of pesticides in soils. Dieldrin is a photo- and biodegradation product of aldrin, which was found in background surface soil. In addition, chloroanilines are formed from the degradation of some pesticides and can be produced during wastewater treatment. For these reasons, these compounds may be attributed to the underlying sludge material. However, 4-chloroaniline is also used in agricultural chemicals.

Of the 20 metals detected in surface soil samples, major-metal ions (aluminum, iron, calcium, magnesium, and potassium) were detected in each of the samples and at higher concentrations than those for other metals. Concentrations ranged from 3,450 to 6,740 mg/kg for aluminum, from 7,190 to 10,400 mg/kg for iron, and from 263 to 1,300 mg/kg for basic cations. Sodium would also be expected to be detected, but was not reported, as described in section 2.6.2. Besides major-metal ions, barium, lead (2.6 to 11.8 mg/kg), manganese (96.4 to 135 mg/kg), and zinc (19.9 to 56.5 mg/kg) were detected in the three surface soil samples. Other heavy metals, consisting of arsenic (0.52 to 0.86 mg/kg), chromium (5.3 to 9.8 mg/kg), cobalt (3 to 3.6 mg/kg), and nickel (3.9 to 5.4 mg/kg), were found in SS-11 and SS-12 (both were collected in September/October 1991 from depths of 0 to 6 inches), while copper (9.9 to 99.3 mg/kg) and vanadium (12 mg/kg) were detected at SS-11 and SS-15, which was collected in April 1992 from depths of 0 to 12 inches. Antimony, mercury, and silver were detected in SS-11 at 78.8, 0.28, and 1.6 mg/kg, respectively. Thallium (0.25 mg/kg) was found in SS-12. Beryllium (0.4 mg/kg) was detected at SS-15. Generally, more heavy metals and higher metal concentrations were measured in SS-11 relative to the other two samples.

With the exception of antimony, all of the metals detected in these surface soil samples were also found in background surface soils. In comparison to the largest metal concentrations detected in background samples, concentrations were less than two times greater than background for barium, manganese, and zinc, but were as much as 20 times greater for copper. Copper was the only metal that was significantly higher in concentration in the Sewage Sludge Area than in the background samples. All of the other metals detected in the surface soil samples were within or below the range detected in the background samples.

Cyanide was not detected in any of the samples. The organic content of the samples was measured at 0.9 and 2.8% in SS-12 and SS-11, respectively.

Bulky Waste Area Results. Three surface soil samples (SS-09, SS-10, and SS-24) were collected from the Bulky Waste Area. The sample located at SS-09 was selected because of the detection of elevated volatile organics in landfill gas at this location. The other sample locations were chosen to characterize the area. During installation of landfill settlement platforms, 2 to 4 feet of fill was encountered at ground surface in this area, whereas refuse was found at ground surface at the eastern perimeter during boring activities (BH-06). This indicates that fill/soil material does not continuously cover the area.

The surface soil samples collected consisted predominantly of topsoil and sand or sand/gravel material. Refuse was not visible, although organic vapors and methane (CH_4) were measured during sampling. Vegetative cover in the area generally consisted of tall grass (section 3.4 of the RI).

Organic compounds were detected at SS-09 and SS-10 but were not detected at SS-24. The types of organic compounds found included chlorinated and aromatic volatiles, ketones, and one phthalate. Acetone, MEK, and PCE were the only compounds detected at concentrations above sample quantitation limits. Pesticides and PCBs were not detected in any of the samples.

Two ketones, acetone (45,000 µg/kg) and MEK (1,400 µg/kg), were detected at SS-09. Acetone was also detected at SS-10 (37 µg/kg). Acetone is commonly found in municipal and industrial landfills from the disposal of solvents or industrial materials, and MEK was identified in industrial waste disposed of in the Solid Waste Area. In addition, production of acetone during degradation processes results in releases to subsurface media.

Chlorinated organics detected at SS-09 include PCE (24 µg/kg) as well as 1,2-DCE, chloroform, and TCE at concentrations less than the sample quantitation limit (8, 2, and 2 µg/kg, respectively).

Tetrachloroethene was also found at SS-10 (3 µg/kg). Three aromatic volatiles consisting of toluene, ethylbenzene, and xylene were also detected at concentrations up to 10 µg/kg at SS-09. Butylbenzylphthalate, which was also found in background surface soil, was detected in SS-10 at a concentration less than the sample quantitation limit (120 µg/kg). These organic compounds are known to have been disposed of during landfill operations, and are typically found in municipal wastes.

Of the 13 metals detected in the surface soil samples, major-metal ions (aluminum, iron, calcium, magnesium, and potassium) were detected at the highest concentrations in all of the samples. Aluminum ranged from 6,500 to 8,940 mg/kg, iron from 9,240 to 11,650 mg/kg and basic cations from 442 to 1,270 mg/kg. Sodium was also detected at similar concentrations, but was not reported. Barium (14.4 to 16.5 mg/kg), manganese (105 to 154 mg/kg), lead (4.3 to 5.6 mg/kg), vanadium (10.2 to 15 mg/kg), and zinc (19.3 to 36 mg/kg) were also found at all three locations. In addition, beryllium and copper (0.52 and 5.6 mg/kg, respectively) were detected at SS-24. Arsenic, chromium, cobalt, and nickel were detected at concentrations from 1.05 to 9.8 mg/kg at SS-09 and SS-10. All of these metals were also found in background surface soil. Concentrations measured in the three bulky waste samples were near (less than two times greater) or within the range found in background surface soil. Cyanide was not detected in any of the surface soil samples. The organic content of the samples ranged from 1.9 to 2.9%.

Solid Waste Area Results. Six surface soil samples were collected from the Solid Waste Area. Surface soil sampling points SS-03, SS-04, and SS-05 were located to evaluate areas where volatile organics were detected in landfill gas. Locations for SS-16 and SS-17 were chosen to further characterize the area, and SS-13 was located near exposed glue-like waste.

During walkovers of the Solid Waste Area many places of exposed refuse were observed. Many of these areas are located near the perimeters of the disposal area, although other exposed areas are also within the boundaries of the disposal area. Two of the samples (SS-03 and SS-05) were collected in areas where there was little topsoil or fill material, and outcrops of exposed refuse occurred. Elevated levels of organic vapors were measured during excavation of these samples. The sample collected at SS-03 consisted of sandy soil intermixed with decomposing refuse and spongy glue-like waste material, while the sample collected at SS-05 was composed of topsoil and refuse. At SS-04, 3 inches of brown weathered sand underlain by a darkly stained sand was sampled. Elevated readings were detected at this location with the FID but not the PID. Similar measurements were made at SS-13, where organic-enriched topsoil, sand, and spongy glue-like waste were collected. A chunk of this waste removed from near SS-13 was analyzed and found to consist of methyl methacrylate, a component of laminants and adhesives (section 4.1 of the RI). Again elevated FID readings were measured, although no PID readings occurred at this location. The other two samples (SS-16 and SS-17) were collected from locations where topsoil and vegetative cover were present. These samples consisted of compacted sand and silt intermixed with pebbles and organic-enriched soil, respectively. There was no visible evidence of refuse in these samples.

Similar findings were also noted during boring and excavation (installation of landfill settlement platforms) activities, as fill material at the ground surface ranged in thickness from 0 to 1.5 feet. In addition, grey or dark-stained soil that was similar to the material collected at SS-04 was also noted at about 0.5 feet below the ground surface at several locations.

The types of volatile organics detected in the surface soils consisted of chlorinated and aromatic volatiles and ketones. Semivolatile organics found include PAHs and phthalates. Pesticides were also detected. PCBs were not detected in any of the samples.

Volatile organics were detected in all of the surface soil samples except at SS-17. Eight of the volatile organics (including 1,1-DCA, 1,2-DCE, toluene, ethylbenzene, xylenes, acetone, and MEK) were generally found in higher concentrations and more often than other volatile organics. Other volatile organics (including PCE, 1,1,1-TCA, 1,1-DCE, chloroform, benzene, 4-methyl-2-pentanone (MIBK), and 2-hexanone were found at concentrations less than sample quantitation limits. Vinyl chloride was also detected.

The majority of chlorinated volatiles were detected in SS-03 and SS-13. Total concentrations at SS-13 were 2,700 µg/kg and at SS-03 were 1,000 µg/kg. As previously mentioned, these samples were collected near refuse and glue-like waste. Chlorinated volatiles were also detected in SS-05 and SS-04. These locations were also sampled near refuse or in discolored fill, respectively. Tetrachloroethene was detected at concentrations below sample quantitation limits (2 to 5 µg/kg) in SS-03, SS-04, and SS-13. 1,1,1-Trichloroethane was also found at 8 µg/kg in SS-03. 1,2-Dichloroethene was found at the highest concentrations in SS-03 (970 µg/kg) and SS-13 (2,400 µg/kg). 1,1-Dichloroethane was also detected in SS-03 (25 µg/kg), while 1,1-DCE was detected in SS-13 (4 µg/kg). Vinyl chloride was also detected at SS-13 (250 µg/kg) and at SS-03 (4 µg/kg). Dichlorinated volatiles and vinyl chloride are common degradation products. In addition, up to 3 µg/kg of chloroform was found at SS-05 and SS-03.

Aromatic volatiles consisting of benzene, toluene, ethylbenzene, and xylenes (BTEX compounds) were present at three of the surface soil samples (SS-03, SS-04, and SS-13). Toluene (58 to 110 µg/kg), ethylbenzene (11 to 21 µg/kg), and xylenes (20 to 84 µg/kg) were found in all three samples. In addition, benzene was detected at 6 µg/kg in SS-03 and SS-13. The highest total BTEX concentrations (220 µg/kg) occurred at SS-13.

The ketones detected in surface soils in this area include acetone, MEK, 2-hexanone, and MIBK. Ketones were detected more often and in the highest total concentrations at SS-04 (160,000 µg/kg), and were also found in SS-03, SS-05, SS-13, and SS-16 at concentrations ranging from 24 to 4,000 µg/kg. Acetone was detected at an elevated concentration (160,000 µg/kg) in SS-04. Acetone concentrations at other locations were lower (75 µg/kg in SS-05 to 4,000 µg/kg in SS-16). 2-Butanone was detected in SS-03, SS-04, and SS-13. 2-Hexanone and MIBK were each detected once at SS-04 at concentrations below sample quantitation limits (3 and 6 µg/kg, respectively).

Isopropanol (IPA) was also detected as a tentatively identified compound (TIC) in SS-04 at a relatively high estimated concentration. Since this was an isolated occurrence at elevated concentrations, it is not suspected of being an artifact from field procedures. In addition, IPA was potentially disposed of in the Solid Waste Area (Kenyon Piece Dyeworks 1979). The other volatile organics are all commonly found in municipal waste, and some of these compounds (MEK, PCE, TCE, and toluene) were components of industrial wastes deposited in this area.

Phthalates and PAHs were detected in several samples at concentrations below sample quantitation limits. Butylbenzylphthalate (41 µg/kg) was detected at SS-03, and diethylphthalate (29 µg/kg) was detected at SS-13. Similar concentrations were also detected in background samples. Ten different PAHs were each detected in SS-04, SS-05, and SS-17 at concentrations ranging from 19 to 170 µg/kg. Two of the PAHs, pyrene (38 µg/kg) and fluoranthene (33 µg/kg), were also detected in SS-13. The detection of PAHs in surface soils in urban areas is common. Debris from fires or ash from boilers or fireplaces may contain PAHs. In the past, used oils were typically applied to the surface of dirt roads or the shoulders of paved roads to reduce airborne dust. Also, fuel oil, asphalt, tar, or heavier fractions of petroleum products contain PAHs, which can be released to the environment either directly or by combustion (i.e., automobile fumes). These PAHs may also be attributed to wastes disposed of in the Solid Waste Area.

The DDT family of pesticides was detected at SS-04, SS-13, SS-16, and SS-17. Except for 4,4'-DDE, concentrations were less than sample quantitation limits. 4,4'-DDT was detected at SS-04 (4.7 µg/kg) and SS-17 (0.9 µg/kg). 4,4'-DDD was detected at SS-13 (5.2 µg/kg) and SS-16 (0.24 µg/kg), and 4,4'-DDE was detected at SS-13 (7.6 µg/kg) and SS-17 (0.33 µg/kg). 4,4'-DDE and 4,4'-DDT were also detected in background surface soil samples. The concentrations found in the Solid Waste Area, however, were generally greater than those in the background samples. The disposal of insecticides, rodenticides, or herbicides in municipal solid waste landfills was not regulated until the mid-1980s. Until then, these chemicals were regularly disposed of by the public. Hence, it is likely that these contaminants would be present in the Site study area.

Major-metals ions (aluminum, iron, calcium, magnesium, and potassium) were detected at concentrations greater than other metals. Sodium was also detected at similar concentrations, but was qualified as nondetected. Barium (15.5 to 20.3 mg/kg), manganese (92.1 to 138 mg/kg), and four heavy metals (copper, lead, vanadium, and zinc at concentrations ranging from 5.4 to 253 mg/kg) were also detected in all of the samples. Arsenic, chromium, copper, and nickel were detected at concentrations from 0.81 to 12.8 mg/kg in the four samples collected from 0 to 6 inches (SS-03, SS-04, SS-05, and SS-13). In addition, beryllium was found at SS-16 and SS-17, while silver was detected at SS-03 and SS-13, and thallium was found at SS-03. Except for silver, all of the metals detected in the Solid Waste Area were also found in background surface soil. The highest concentrations tended to occur at SS-13 or SS-03. Of the metals detected, copper concentrations were as much as 50 times greater than found in background surface soils. However, based on the available data, no statistical difference was evident between the metal concentrations, including copper, and concentrations in background surface soil

(Appendix D of the RI).

Cyanide was not reported in any of the surface soil samples. The organic content of the soil ranged from 2.3 to 9.4%.

Non-disposal Areas Results. Nine sampling locations were selected outside of the disposal area boundaries. Two surface soil samples, SS-07 and SS-08, were collected on residential property to evaluate volatile organics detected in soil gas. Samples collected from these locations consisted of roots and organic-enriched soil with sand. Organic vapors were measured at SS-07. Locations for SS-18, north of the Solid Waste Area, and SS-22 and SS-23, between the Bulky Waste Area and Saugatucket River, were positioned near leachate outbreaks. Samples from these locations were characterized by dark organic matter intermixed with sand, silt, and roots. An orange leachate outbreak was observed about 3 feet from SS-23. Surface soil samples SS-19 and SS-20 were collected south of the Solid Waste Area, in a wooded area near Mitchell Brook. Samples consisted of decomposing organic matter intermixed with sand and silt. In an open area, approximately 150 feet south of the Transfer Station Road, SS-06 was collected. SS-21 was collected in a low-lying drainage area next to the eastern perimeter of the Solid Waste Area. The sample was collected from a 4-by-25-foot area with little to no vegetation and orange-stained sand that was presumed to be a dried-up leachate seep since a drainage swale was identified near this location (Figure 7). Orange-stained sandy soil was collected at this location.

Volatile organics (chlorinated and aromatic volatiles and ketones) were detected at five locations. Chlorinated volatiles were detected at concentrations below sample quantitation limits in three locations. Tetrachloroethene was found at 4 µg/kg in SS-08, while 1,1-DCA and 1,2-DCE were found in SS-07 at 2 (field duplicate only) and 6 µg/kg, respectively. SS-07 was collected near an area where leachate seeps were observed in past years by the residents and elevated volatile organic concentrations were measured in landfill gas a few feet away. Chloroform was detected in SS-06 (2 µg/kg), which is less than 100 feet from where landfill gas was detected. Concentrations of BTEX compounds ranged from 2 to 12 µg/kg. Ethylbenzene, toluene, and xylene were detected at SS-22, and toluene was found at SS-23. These compounds were also detected in a nearby leachate seep (section 4.2.3 of the RI). Acetone and MEK were found in SS-06, SS-07 (in field duplicate), SS-08, and SS-22 at concentrations ranging from 15 to 4,400 µg/kg and 23 to 33 µg/kg, respectively. Volatile organics were not detected at three locations: SS-19, SS-20, and SS-21.

Diethylphthalate (27 to 42 µg/kg) was detected in SS-20 and SS-22 at concentrations similar to those found in background surface soil. Ten individual PAHs, at concentrations ranging from 31 to 100 µg/kg, were detected at SS-07. While individual concentrations were below sample quantitation limits, total concentrations equaled 560 µg/kg. At this location, these compounds have likely resulted from runoff from Rose Hill Road, approximately 10 feet away. Several PAHs were also found in background surface soil at similar concentrations.

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