WehranEnviroTech

SCANNED

PHASE II [illegible]
FOR THE FORMER [illegible] FACILITY
[illegible]
MASSACHUSETTS

Prepared For:
MARTIN MARIETTA CORPORATION
Environmental Programs
[illegible] Boulevard
King of Prussia, PA 19406

October 19[illegible]

Wehran Envirotech [illegible]
Andover, Massachusetts

Environmental Engineers • Scientists • Constructors

SCANNED

PHASE III REMEDIAL ACTION PLAN

FOR THE FORMER GENERAL ELECTRIC FACILITY
50 FORDHAM ROAD, WILMINGTON/NORTH READING, MASSACHUSETTS

Prepared For

MARTIN MARIETTA CORPORATION
Environmental Programs
230 East Goddard Boulevard
King of Prussia, PA 19406

October 1993

WEHRAN ENGINEERING CORPORATION
Andover, Massachusetts

Environmental Engineers • Scientists • Constructors

Lockheed Martin
Burbank Program Office
2550 N. Hollywood Way, #305 Burbank, CA 91505-1055
Facsimile 818-847-0170

LOCKHEED MARTIN

Via Federal Express
RNH0297/100

Mr. Steve Johnson
Section Chief
Site Management Branch
Department of Environmental Protection
10 Commerce Way
Woburn, Massachusetts 01801

Subject: **Former General Electric Facility**
50 Fordham Road, Wilmington
DEP RTN 3-0518

Reference: **Comprehensive Response Action Transmittal Form &**
Phase I Completion Statement

Dear Mr. Johnson:

In accordance with the Massachusetts Department Environmental Protection (DEP) request in letter dated January 24, 1997, Lockheed Martin herein submits the referenced Transmittal Form for the Phase III Remedial Action Plan (RAP) submitted to the DEP on October 15, 1993. As indicated to your office during our meeting on December 3, 1996 and subsequently by phone, Lockheed Martin was uncertain as to the applicability of the form submittal given that the RAP was submitted prior to the existence of the Tier 1A permit for the site, and, due to the fact that the Licensed Site Professional (LSP) for the site has changed since 1993.

However, in response to the aforementioned DEP letter wherein the DEP acknowledges that the Transmittal Form will be submitted and dated in 1997 for the RAP submitted in accordance with the Massachusetts Contingency Plan during October 1993, Lockheed Martin herein provides the Transmittal Form dated February 10, 1997 and signed by the LSP involved with the original 1993 Phase III submittal.

If you have any questions regarding this submittal, please do not hesitate to call Michelle Levesque of my staff at (818) 847-0896.

Sincerely,

R. N. Helgerson
Director

cc w/ enclosure: R. Lamkin
A. Valja

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC-108

COMPREHENSIVE RESPONSE ACTION TRANSMITTAL FORM & PHASE I COMPLETION STATEMENT

Pursuant to 310 CMR 40.0484 (Subpart D) and 40.0800 (Subpart H)

Release Tracking Number: 3 - 518

A. SITE LOCATION:

Site Name: (optional) Former General Electric Facility

Street: 50 Fordham Road   Location Aid:

City/Town: Wilmington   ZIP Code: 01887-0000

Related Release Tracking Numbers that this Form Addresses: 3-0518

Tier Classification: (check one of the following) ☑ Tier IA ☐ Tier IB ☐ Tier IC ☐ Tier II ☐ Not Tier Classified

If a Tier I Permit has been issued, state the Permit Number: 83052

B. THIS FORM IS BEING USED TO: (check all that apply)

☐ Submit a **Phase I Completion Statement**, pursuant to 310 CMR 40.0484 (complete Sections A, B, C, G, H, I and J).

☐ Submit a **Phase II Scope of Work**, pursuant to 310 CMR 40.0834 (complete Sections A, B, C, G, H, I and J).

☐ Submit a final **Phase II Comprehensive Site Report and Completion Statement**, pursuant to 310 CMR 40.0836 (complete Sections A, B, C, D, G, H, I and J).

☑ Submit a **Phase III Remedial Action Plan and Completion Statement**, pursuant to 310 CMR 40.0862 (complete Sections A, B, C, G, H, I and J).

☐ Submit a **Phase IV Remedy Implementation Plan**, pursuant to 310 CMR 40.0874 (complete Sections A, B, C, G, H, I and J).

☐ Submit an **As-Built Construction Report**, pursuant to 310 CMR 40.0875 (complete Sections A, B, C, G, H, I and J).

☐ Submit a **Phase IV Final Inspection Report and Completion Statement**, pursuant to 310 CMR 40.0878 and 40.0879 (complete Sections A, B, C, E, G, H, I and J).

☐ Submit a periodic **Phase V Inspection & Monitoring Report**, pursuant to 310 CMR 40.0892 (complete Sections A, B, C, G, H, I and J).

☐ Submit a final **Phase V Inspection & Monitoring Report and Completion Statement**, pursuant to 310 CMR 40.0893 (complete Sections A, B, C, F, G, H, I and J).

You must attach all supporting documentation required for each use of form indicated, including copies of any Legal Notices and Notices to Public Officials required by 310 CMR 40.1400.

C. RESPONSE ACTIONS:

☐ Check here if any response action(s) that serves as the basis for the Phase submittal(s) involves the use of Innovative Technologies. (DEP is interested in using this information to create an Innovative Technologies Clearinghouse.)

Describe Technologies:

D. PHASE II COMPLETION STATEMENT:

Specify the outcome of the Phase II Comprehensive Site Assessment:

☐ Additional Comprehensive Response Actions are necessary at this Site, based on the results of the Phase II Comprehensive Site Assessment.

☐ The requirements of a Class A Response Action Outcome have been met and a completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ The requirements of a Class B Response Action Outcome have been met and a completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ Rescoring of this Site using the Numerical Ranking System is necessary, based on the results of the final Phase II Report.

E. PHASE IV COMPLETION STATEMENT:

Specify the outcome of Phase IV activities:

☐ Phase V operation, maintenance or monitoring of the Comprehensive Response Action is necessary to achieve a Response Action Outcome. (This site will be subject to a Phase V Operation, Maintenance and Monitoring Annual Compliance Fee.)

☐ The requirements of a Class A Response Action Outcome have been met. No additional operation, maintenance or monitoring is necessary to ensure the integrity of the Response Action Outcome. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ The requirements of a Class C Response Action Outcome have been met. No additional operation, maintenance or monitoring is necessary to ensure the integrity of the Response Action Outcome. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

SECTION E IS CONTINUED ON THE NEXT PAGE

Massachusetts Department of Environmental Protection
Bureau of Waste Site Cleanup

BWSC-108

COMPREHENSIVE RESPONSE ACTION TRANSMITTAL FORM & PHASE I COMPLETION STATEMENT

Pursuant to 310 CMR 40.0484 (Subpart D) and 40.0800 (Subpart H)

Release Tracking Number: 3 - 518

E. PHASE IV COMPLETION STATEMENT: (continued)

☐ The requirements of a Class C Response Action Outcome have been met. Further operation, maintenance or monitoring of the remedial action is necessary to ensure that conditions are maintained and that further progress is made toward a Permanent Solution. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

Indicate whether the operation and maintenance will be Active or Passive. (Active Operation and Maintenance is defined at 310 CMR 40.0006.):

◯ Active Operation and Maintenance ◯ Passive Operation and Maintenance

(Active Operation and Maintenance makes the Site subject to a Post-RAO Class C Active Operation and Maintenance Annual Compliance Fee.)

F. PHASE V COMPLETION STATEMENT:

Specify the outcome of Phase V activities:

☐ The requirements of a Class A Response Action Outcome have been met and a completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ The requirements of a Class C Response Action Outcome have been met. No additional operation, maintenance or monitoring is necessary to ensure the integrity of the Response Action Outcome. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

☐ The requirements of a Class C Response Action Outcome have been met. Further operation, maintenance or monitoring of the remedial action is necessary to ensure that conditions are maintained and that further progress is made toward a Permanent Solution. A completed Response Action Outcome Statement (BWSC-104) will be submitted to DEP.

Indicate whether the operation and maintenance will be Active or Passive. (Active Operation and Maintenance is defined at 310 CMR 40.0006.):

◯ Active Operation and Maintenance ◯ Passive Operation and Maintenance

(Active Operation and Maintenance makes the Site subject to a Post-RAO Class C Active Operation and Maintenance Annual Compliance Fee.)

G. LSP OPINION:

I attest under the pains and penalties of perjury that I have personally examined and am familiar with the information contained in this transmittal form, including any and all documents accompanying this submittal. In my professional opinion and judgment based upon application of (i) the standard of care in 309 CMR 4.02(1), (ii) the applicable provisions of 309 CMR 4.02(2) and (3), and (iii) the provisions of 309 CMR 4.03(5), to the best of my knowledge, information and belief,

> *if Section B indicates that a* ***Phase I, Phase II, Phase III, Phase IV or Phase V Completion Statement*** *is being submitted*, the response action(s) that is (are) the subject of this submittal (i) has (have) been developed and implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal;

> *if Section B indicates that a* ***Phase II Scope of Work*** *or a* ***Phase IV Remedy Implementation Plan*** *is being submitted*, the response action(s) that is (are) the subject of this submittal (i) has (have) been developed in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal;

> *if Section B indicates that an* ***As-Built Construction Report*** *or a* ***Phase V Inspection and Monitoring Report*** *is being submitted*, the response action(s) that is (are) the subject of this submittal (i) is (are) being implemented in accordance with the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, (ii) is (are) appropriate and reasonable to accomplish the purposes of such response action(s) as set forth in the applicable provisions of M.G.L. c. 21E and 310 CMR 40.0000, and (iii) complies(y) with the identified provisions of all orders, permits, and approvals identified in this submittal.

I am aware that significant penalties may result, including, but not limited to, possible fines and imprisonment, if I submit information which I know to be false, inaccurate or materially incomplete.

☑ Check here if the Response Action(s) on which this opinion is based, if any, are (were) subject to any order(s), permit(s) and/or approval(s) issued by DEP or EPA. If the box is checked, you MUST attach a statement identifying the applicable provisions thereof.

LSP Name: Charles Myette LSP #: 3264 Stamp:

Telephone: 508-682-1980 Ext.:

FAX: (optional) 508-975-2065

Signature: Charles Myette

Date: 2-10-97

COMMONWEALTH OF MASSACHUSETTS
CHARLES F. MYETTE
No. 3264
REGISTERED
LICENSED SITE PROFESSIONAL

Massachusetts Department of Environmental Protection **BWSC-108**
Bureau of Waste Site Cleanup

DEP

COMPREHENSIVE RESPONSE ACTION TRANSMITTAL FORM & PHASE I COMPLETION STATEMENT

Pursuant to 310 CMR 40.0484 (Subpart D) and 40.0800 (Subpart H)

Release Tracking Number 3 - 518

H. PERSON UNDERTAKING RESPONSE ACTION(S):

Name of Organization: Lockheed Martin Corporation

Name of Contact: Ronald N. Helgerson Title: Director

Street: 2550 N. Hollywood Way, Suite 301

City/Town: Burbank State: CA ZIP Code: 91505-0000

Telephone: 818-847-6927 Ext.: FAX: (optional) 617-272-4026

☐ Check here if there has been a change in the person undertaking the Response Action.

I. RELATIONSHIP TO SITE OF PERSON UNDERTAKING RESPONSE ACTION(S): (check one)

☑ RP or PRP Specify: ☑ Owner ◯ Operator ◯ Generator ◯ Transporter Other RP or PRP:

☐ Fiduciary, Secured Lender or Municipality with Exempt Status (as defined by M.G.L. c. 21E, s. 2)

☐ Agency or Public Utility on a Right of Way (as defined by M.G.L. c. 21E, s. 5(j))

☐ Any Other Person Undertaking Response Action Specify Relationship:

J. CERTIFICATION OF PERSON UNDERTAKING RESPONSE ACTION(S):

I, Ronald N. Helgerson, attest under the pains and penalties of perjury (i) that I have personally examined and am familiar with the information contained in this submittal, including any and all documents accompanying this transmittal form, (ii) that, based on my inquiry of those individuals immediately responsible for obtaining the information, the material information contained in this submittal is, to the best of my knowledge and belief, true, accurate and complete, and (iii) that I am fully authorized to make this attestation on behalf of the entity legally responsible for this submittal. I/the person or entity on whose behalf this submittal is made am/is aware that there are significant penalties, including, but not limited to, possible fines and imprisonment, for willfully submitting false, inaccurate, or incomplete information.

By: [signature] Title: Director
(signature)

For: Lockheed Martin Corporation Date: 2/27/97
(print name of person or entity recorded in Section H)

Enter address of the person providing certification, if different from address recorded in Section H:

Street:

City/Town: State: ZIP Code:

Telephone: Ext.: FAX: (optional)

YOU MUST COMPLETE ALL RELEVANT SECTIONS OF THIS FORM OR DEP MAY RETURN THE DOCUMENT AS INCOMPLETE. IF YOU SUBMIT AN INCOMPLETE FORM, YOU MAY BE PENALIZED FOR MISSING A REQUIRED DEADLINE.

ATTACHMENT A

The Response Actions upon which this opinion is based conforms to the provisions of M.G.L. 21A Sections 19-19J, 309 CMR 1.00-8.00, M.G.L 21E, 310 CMR 40.0000, and relevant guidance documents as they existed on October 15, 1993. It should be noted that Charles Myette is no longer the LSP-of-Record for the site, however, for administrative completeness the Department of Environmental Protection is requiring submittal of this Transmittal Form. It should also be noted that the site has a Tier IA permit but at the time the Phase III Remedial Action Plan was submitted the permit was not in effect.

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1.0 INTRODUCTION

1.1 PURPOSE OF THE REMEDIAL ACTION PLAN

This Phase III Remedial Action Plan was prepared pursuant to the requirements set forth in the Massachusetts Contingency Plan (MCP) 310 CMR40.0850. Consistent with the MCP, the Phase III Remedial Action Plan includes:

(1) Identification of remedial action alternatives;

(2) Evaluation of remedial action alternatives; and

(3) Selection of a remedial action alternative.

The purpose of this Remedial Action Plan is to identify and evaluate a range of remedial alternatives for the 50 Fordham Road site. This Plan is based on the data and interpretations presented in the Phase II Report (GZA, 1990), the Phase II Supplemental Investigation (Wehran, 1991), the Second Supplemental Phase II Investigation (Wehran, 1992) and, the Risk Characterization performed by ADL (1991).

1.2 REPORT ORGANIZATION

This Remedial Action Plan contains eight sections. Section 1.0 presents background information on the 50 Fordham Road site, discusses the previous remedial actions at the site, and summarizes the results of the Phase II Investigations. Section 2.0 summarizes the results of the risk assessment conducted by Arthur D. Little, Inc., identifies appropriate remedial action objectives and develops cleanup levels for groundwater, soil and sediment. The MCP requires an initial screening of remedial action alternatives to identify those remedial action alternatives that are reasonably likely to be feasible and achieve a level of no significant risk. Due to the complexity of the site (multiple locations, media and types of contaminants) this initial screening was carried out in two steps in Sections 3.0 and 4.0. Section 3.0 describes the identification and screening of technologies based on effectiveness, implementability and relative cost. In Section 4.0, feasible technologies are assembled into soil treatment, groundwater collection, and groundwater treatment components of the remedial action alternatives. These components are then evaluated and screened to reduce the number of remedial alternatives. In Section 5.0, the remedial action alternatives are evaluated on the basis of effectiveness, reliability, implementability, cost, risk, benefits, timeliness and non-pecuniary interests. Based on a comparative analyses in section 6.0, one remedial action alternative is selected. Section 7.0 presents the selected remedial action alternative for the 50 Fordham Road site, with a preliminary implementation schedule. Section 8.0 includes a list of references.

1.3 BACKGROUND

1.3.1 Site Location and Description

The 50 Fordham Road property (hereafter referred to as the "property") is an approximately 13 acre parcel of land situated east of Fordham Road and north of Concord Street within an industrial park in Wilmington and North Reading, Massachusetts. General Electric Company's Aerospace Division (GE) occupied the property from 1968 until 1989. Martin Marietta Corporation recently acquired GE's Aerospace Division. Ametek Aerospace Products, Inc. (Ametek) is the current occupant of the property.

The property is abutted to the west by Fordham Road, and industrial parcels to the west of Fordham Road; by Converse property to the south; and by wooded wetlands to the east and north. The property is located at Universal Transverse Mercator (UTM) coordinates of 4,714,000 meters North, 324,500 meters East (Zone 19), and at a latitude and longitude of 43 degrees, 33 minutes, 37 seconds North and 71 degrees, 8 minutes, 7 seconds East, respectively.

A regional topographic plan showing the 50 Fordham Road property is presented as Sheet 1. DEP has required (for purposes of the MCP) that the area to be addressed by this remedial action plan is bounded by Fordham Road to the west, till/bedrock uplands to the north and northeast, and Concord Street to the south and southeast.

The Stickney Well is located approximately 500 feet northeast of the property. The Well is a Town of North Reading public water supply well which was installed in 1964 and closed in 1978 due to chlorinated solvent contamination.

A map of the former GE operation is presented in Figure 1-1 and shows approximate locations of the buildings and other features discussed below. Predominant man-made structures include one small and three large buildings (designated Buildings 1, 1A, 2, and 3) situated on the western side of the property; a large paved parking area located on the eastern side of the property; and a wastewater (sewage) treatment facility (WWTF) located north of the parking area.

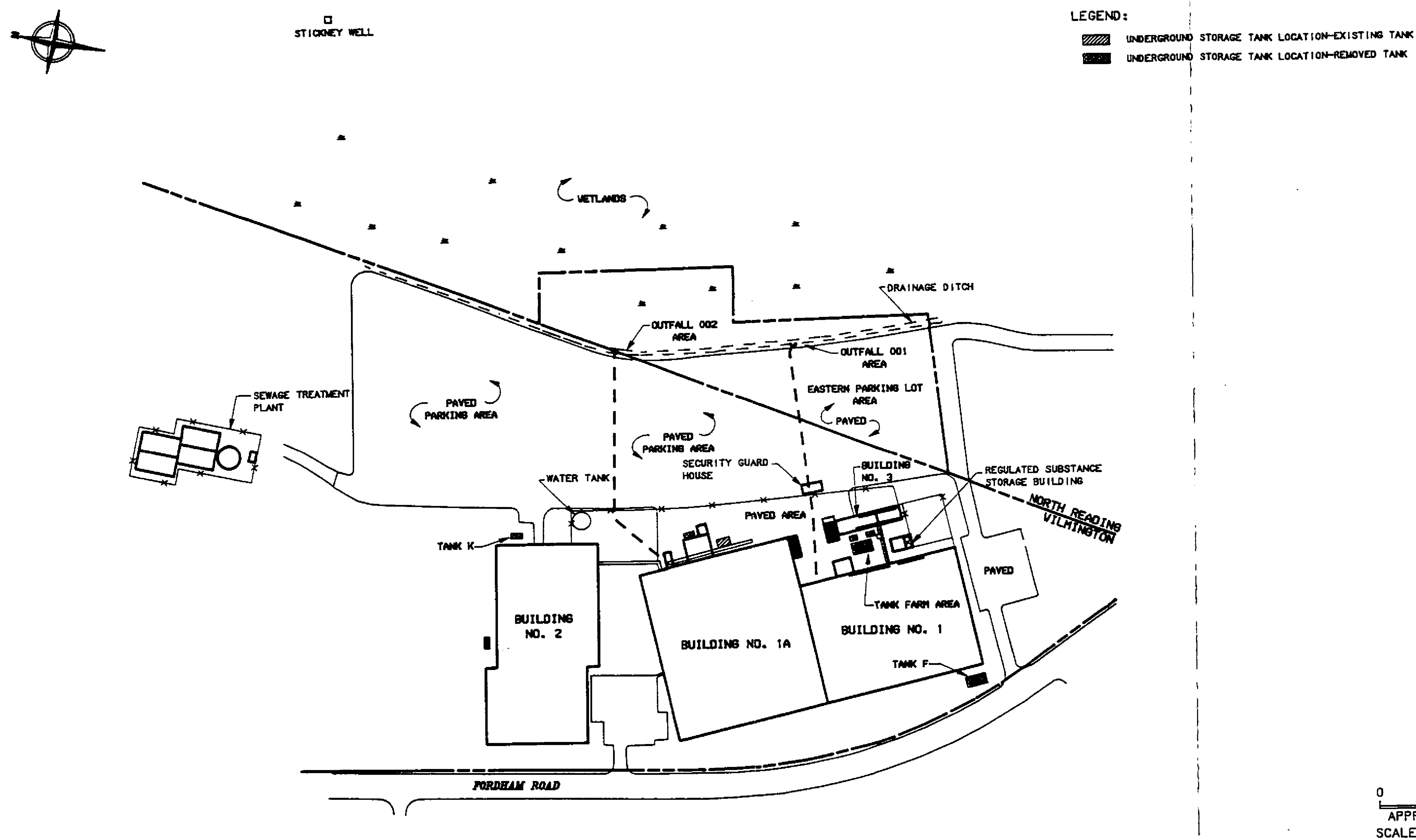


FIGURE 1-1

ON-PROPERTY SITE MAP

MARTIN MARIETTA CORPORATION
WILMINGTON/N. READING, MASSACHUSETTS

NOTE:
1. BASE MAP PROVIDED TO WEHRAN ENGINEERING BY AUTOMATED COMPLIANCE SYSTEMS, INC. (ACS) BRIDGEWATER, NJ. ACS MAP DEVELOPED FROM PLAN PROVIDED BY GENERAL ELECTRIC COMPANY ENTITLED "SITE PLAN", UNDATED, ORIGINAL SCALE = 1" - 40'.

Ametek currently discharges certain cooling and sanitary wastewater to the WWTF north of the main facility. Storm and non-contact cooling waters drain to two drainlines extending under the parking area which discharge at two outfalls, designated 001 and 002. Outfalls 001 and 002 discharge to a drainage ditch/wetlands area at the east edge of the property (Figure 1-1).

1.3.2 Geology and Hydrology

1.3.2.1 Regional Geology

According to Fenneman (1938), the Wilmington/North Reading area lies within the Ipswich River basin within the Seaboard Lowland Province of the New England physiographic province. This province is characterized by extensive glacial outwash and till deposits overlying igneous and metamorphic rock units, which are deeply entrenched by pre-glacial valleys. Sheet 1 shows that the topography of the area is irregular, reflecting surficial geologic features such as bedrock and till hills, ice-channel fillings, kame terraces and deltas, and swamp deposits.

Numerous hydrogeologic investigations have been conducted in the study area spanning the last 30 years. The CDM (1986) report references a significant portion of the earlier work related to development of the local water supply. The GZA (1990) and Wehran (1991 and 1992) reports offer additional information concerning the geology and hydrogeology of the area. Sheet 2 portrays approximate locations of groundwater monitoring points installed by CDM, GZA, Wehran, and others within the study area. This map also shows the location of transect lines used to develop approximate geologic cross-sections of the area, which will be discussed below.

The primary pre-glacial valley in the region lies just south of the study area, trends east-west along the North Reading/Reading town line and approximately underlies the current course of the upstream section of the Ipswich River. This pre-glacial valley is at least 110 feet deep and contains thick glacial till and sand/gravel deposits (Baker et al., 1964). Another major pre-glacial valley exists within the study area (located just north of Concord Street and east/southeast of the property) and has a localized depth greater than 70 feet and is filled with glacial deposits that underlie the wetland area. This summary assumes without verification the accuracy of the data presented on Sheet 3 (approximate configuration of the bedrock surface) Sheet 4 (approximate thickness of regional unconsolidated deposits) and Sheets 5 and 6 (conceptual geologic cross sections) which are based on widely spaced data points from a variety of sources over different periods of time.

Overburden (unconsolidated) deposits in the area include glacial stratified drift and till deposits as well as horizontally extensive, although thin (10 to 15 feet thick), swamp (peat) deposits. Glacial till is usually found directly overlying bedrock and is generally less than 10 feet thick. In the preglacial valleys much thicker deposits of till are found. The till varies from a sandy, bouldery, loosely compacted deposit, referred to as the "upper till", to a denser, fissile, and more clayey "lower" till. The "upper" till is an ablation till and is often interpreted to be a younger, re-worked ice and water-laid deposit, whereas the "lower" till is a basal till formed during the initial advance of the ice-sheet (Castle, 1959).

The exposed stratified drift materials in the area are dominated by ice-contact deposits such as kame terraces, kame plains, kame deltas, and ice-channel fillings. Sand and gravel outwash deposits may underlie the swamp (peat) deposits mapped by Oldale (1962) and Castle (1959). Local explorations have revealed the sand and gravel in the area to have a significant boulder fraction; dense impenetrable boulder strata (pavements) at depth have been inferred in some areas (GZA, 1990). The hydraulic conductivity of the glacial sands and gravels in this area can be on the order of several hundred feet per day or more (CDM, 1986).

The principal bedrock lithologies of the Wilmington/North Reading area are granite, gneiss, diorite, gabbro, and quartzite (Emerson, 1917). The hydraulic conductivity of bedrock in the area is generally low, yielding only small volumes of water suitable for domestic use (Baker, 1964).

1.3.2.2 Local Geology

The following four reports were used to compile a summary of localized geologic conditions: CDM (1986), GZA (1990), and Wehran (1991 and 1992). The regional geologic cross sections (Sheets 5 and 6) encompass both on-property and off-property areas. All monitoring wells referenced in the following sections are included on Sheet 2. Logs for the "DP", "GZA", and "PZ" borings are included in the GZA (1990) report, whereas, the "WE" borings are included in the Wehran (1991 and 1992) reports. The CDM (1986) report includes logs for the "MW" borings in the wetlands adjacent to the property.

On-Property Area

The majority of the property is underlain by approximately two to eight feet of fill material consisting primarily of silty, fine to coarse sand with varying amounts of gravel. Exceptions to this include an area to the east of Building 1A, where gravel was not observed in the upper overburden, and the area to the east of and between Buildings 1A and Building 2 where silty sand was observed in the upper six feet. In the vicinity of the Tank F Area (west of Building 1), fill was observed to extend to approximately 12 feet below the ground surface (bgs). This is likely due to refilling the excavation following removal of the tank formerly in this area. In borings GZA-1, GZA-2, and PZ-9, located in the northern portion of the property, fill was not observed in the upper overburden. However, a layer of organic peat varying in thickness from approximately two and one-half feet to six feet was encountered in these borings at ground surface.

Where present, the fill material is in turn underlain by two different strata. In the eastern portion of the property, peat, varying in thickness from 2 to 12 feet, was observed to underlie the fill from depths of approximately 5 to 19 feet bgs. It appears that the peat is continuous in overburden material in the general area abutting the wetlands to the east, however it was not observed in borings advanced west of this area, except as previously noted at PZ-9.

Beneath the peat, where present, and beneath the fill in the remaining portions of the property (i.e., beneath the entire property), the second stratum observed in overburden material consists primarily of fine to coarse sand and gravel with trace to little amounts of silt. Observations from boring logs indicate that the silt fraction in this stratum tends to be most prevalent in the upper portions while increasing amounts of gravel, and in the southwest portion of the property, cobbles and boulders, tend to replace the silt component with depth. Based on boring logs, this sand and gravel stratum appears to be in direct contact with the bedrock surface at the property with basal till being absent.

Based upon rock cores collected at the property by GZA (1990) and Wehran (1991 and 1992), two types of plutonic bedrock underlie the overburden material. Andover Granite was observed in rock cores from most bedrock monitoring points, while at monitoring locations GZA-101, GZA-104, GZA-107, GZA-108, and PZ-3, Sharpner's Pond Diorite was observed. With the exception of GZA-104, where the diorite was observed above the granite, the diorite was observed to underlie the granite. Where both rock types were observed, granitic or dioritic intrusions were generally observed.

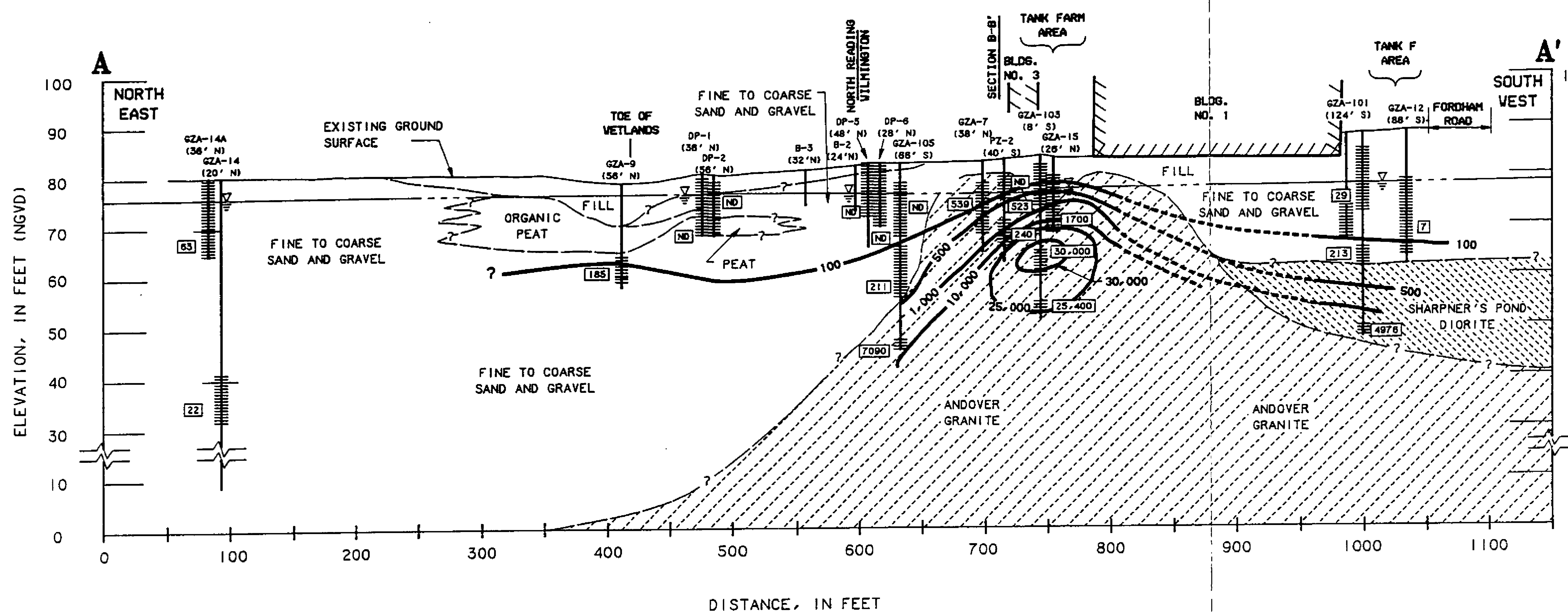
As shown in Figures 1-2 and 1-3, the bedrock surface appears to be quite variable in the vicinity of the property. One of the most prominent features of the bedrock topography is the existence of a bedrock knob in the vicinity of Building 1 and Building 3. At monitoring locations DP-9, DP-10, and PZ-3, bedrock was observed approximately four feet below ground surface (bgs). Furthermore, bedrock was observed to outcrop near the entrance driveway for the facility south of Building 3. Bedrock appears to slope relatively steeply downward to the west from the area of the buildings (approximately five feet bgs) to approximately 25 feet bgs near GZA-101 and GZA-13. Bedrock also appears to slope relatively steeply downward to greater than 40 feet bgs to the east, near the eastern edge of the parking lot. The slope of the bedrock surface toward the east is more gentle in the northern portion of the site where bedrock was observed approximately 30 feet bgs in the area of PZ-7 and PZ-9 and approaching 40 feet bgs near the wetlands. This summary assumes without further verification that further east/southeast of the property in the wetlands, the bedrock is anticipated to continue to slope downward to a maximum depth greater than or equal to 70 feet bgs, although actual bedrock coring data have not been collected to confirm this. Sheet 3 shows the approximate configuration of the bedrock surface.

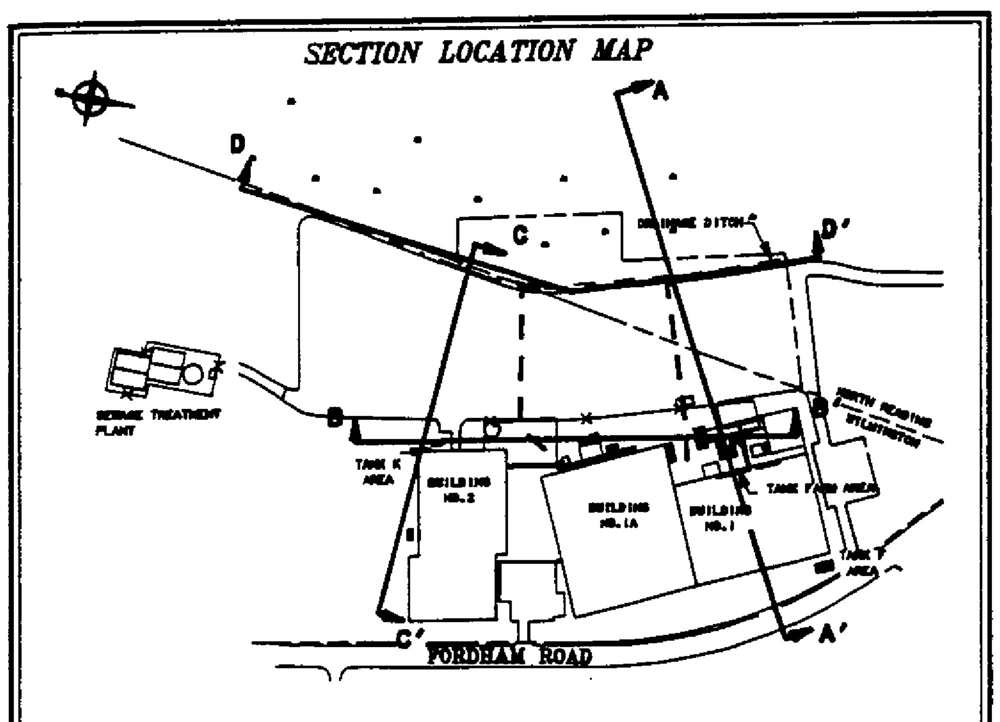
Rock cores collected from on-property locations by GZA (1990) and Wehran (1991 and 1992) indicate that approximately the upper 5 to 15 feet of the bedrock is moderately to heavily fractured while zones beneath this are competent.

Concord Street Area

For the area along Concord Street, GZA (1990) identified three buried valleys which may be tributary to the Ipswich River valley (see regional cross section D-D' on Sheet 6). The deepest valley is located near STM-2. (STM-2 is a piezometer cluster located approximately 3,000 feet east/southeast of the property.) Two other minor valleys approximately 30 to 40 feet deep were identified between STM-3 and STM-8.

The Concord Street borings encountered thicker and generally coarser sections of glacial deposits than those found on the property (Sheet 6). Boring STM-2, centered in the deepest valley, encountered over 60 feet of sandy strata overlying 10 feet of basal till. A





LEGEND:

GZA-5 (16'N)	MONITORING WELL/BORING LOCATION OFFSET IN FEET AND DIRECTION FROM CROSS-SECTION
(symbol)	SCREENED INTERVAL
(symbol)	APPROXIMATE WATER TABLE SURFACE OCTOBER 30, 1989
(symbol)	GEOLOGIC CONTACT
1700	TOTAL CHLORINATED HYDROCARBON CONCENTRATION IN GROUNDWATER (µg/l) (AS OBSERVED BY GZA, 1989)
ND	NOT DETECTED
1,000	LINE OF EQUAL TOTAL CHLORINATED HYDROCARBON CONCENTRATION, (AS OBSERVED BY GZA, 1989), CONTOUR INTERVAL VARIES
NGVD	NATIONAL GEODETIC VERTICAL DATUM

NOTE:
CONCENTRATION ISOCONS SHOWN INCLUDE INTERPOLATION DUE TO OFFSET DISTANCES.

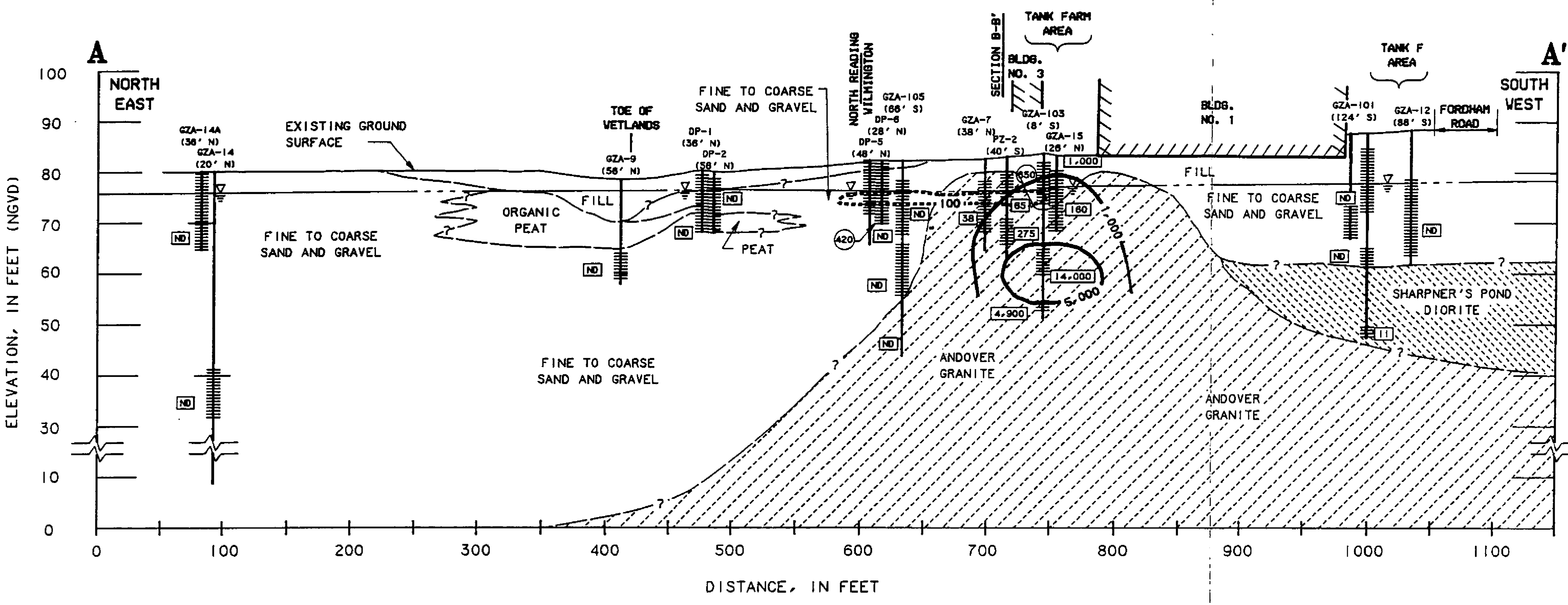
VERTICAL SCALE: 1" = 20'
HORIZONTAL SCALE: 1" = 80'

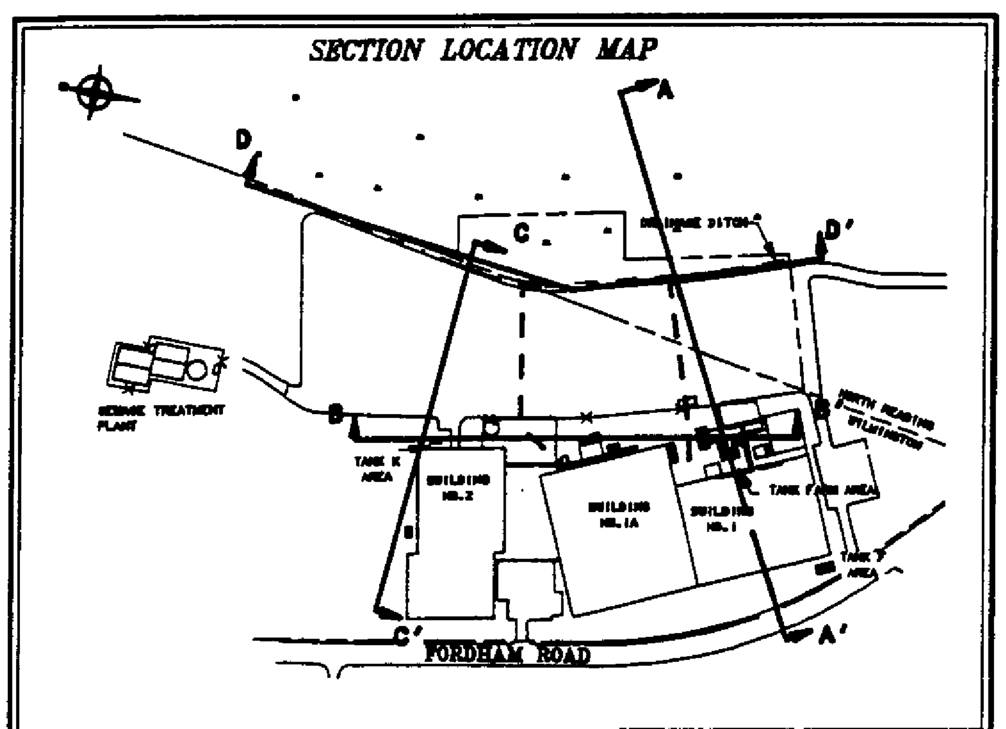
1-6

FIGURE 1-2

ESTIMATED TOTAL CHLORINATED HYDROCARBON CONCENTRATIONS IN OVERBURDEN AND BEDROCK

MARTIN MARIETTA CORPORATION
WILMINGTON/N. READING, MASSACHUSETTS





LEGEND:

GZA-5 (16'N)	MONITORING WELL LOCATION OFFSET IN FEET AND DIRECTION FROM CROSS-SECTION
(symbol)	SCREENED INTERVAL
(symbol)	APPROXIMATE WATER TABLE SURFACE OCTOBER 30, 1989
(symbol)	GEOLOGIC CONTACT
BTEX	BENZENE, TOLUENE, ETHYLBENZENE AND TOTAL XYLENES
TPH	TOTAL PETROLEUM HYDROCARBONS
(420)	TPH CONCENTRATION IN GROUNDWATER (mg/l) (AS OBSERVED BY WEHRAN, 1991)
[14,000]	TOTAL BTEX CONCENTRATION IN GROUNDWATER (µg/l) (AS OBSERVED BY GZA, 1989)
......100	LINE OF EQUAL TPH CONCENTRATION, (mg/l), (AS OBSERVED BY WEHRAN, 1991)
—1,000	LINE OF EQUAL BTEX CONCENTRATION IN GROUNDWATER, (µg/l), (AS OBSERVED BY GZA, 1989), CONTOUR INTERVAL VARIES
NGVD	NATIONAL GEODETIC VERTICAL DATUM

NOTE:
CONCENTRATION ISOCONS SHOWN INCLUDE INTERPOLATION DUE TO OFFSET DISTANCES.

VERTICAL SCALE: 1" = 20'
HORIZONTIAL SCALE: 1" = 80'

FIGURE 1-3

ESTIMATED TPH AND BTEX CONCENTRATIONS IN OVERBURDEN AND BEDROCK

MARTIN MARIETTA CORPORATION

fairly continuous sand and gravel strata ranging in thickness from 15 to 40 feet was encountered west of the deepest valley. In some cases, this strata is overlain by lenses of sand and silty sand. Up to 20 feet of basal till underlying the sand and gravel was encountered in several borings, including STM-3, STM-8, and STM-6.

Bedrock coring along Concord Street encountered Sharpner's Pond Diorite and Andover Granite as well as an unnamed "Silurian granite" mapped by Zen (1983). Logs for the "STM" soil borings and rock corings are summarized in the GZA (1990) report.

Wetlands Area

The soil in the wetlands located just east/southeast of the property consist predominantly of stratified drift deposits overlain by peat deposits and underlain by till and bedrock (CDM, 1986 and GZA, 1990). These reports suggest that the generalized stratification of these soil types is as illustrated in regional cross-sections A-A' and B-B' (Sheet 5). The stratified drift consists of layers of outwash deposits (sand and silt, little gravel and trace boulders) and ice contact deposits (sand and gravel, little silt). The peat layer ranges in thickness from 10 to 15 feet on average. The stratified drift deposits vary in thickness from greater than 50 feet at the Stickney Well, to 70 feet at GZA-14, to 30 feet at MW-4A. The basal till layer ranges in thickness from 5 to 15 feet. Available data suggests depth to bedrock in this area varies from approximately 55 to greater than 70 feet below ground surface, as depicted in the regional isopach map of overburden deposits in Sheet 4.

1.3.2.3 Regional Surface Water Hydrology and Drainage

Drainage Patterns

As shown on Sheet 1, the Ipswich River is located just south of the study area and flows east, delineating the Reading/North Reading town line. According to Baker et al., (1964), surface water gradients along the Ipswich River valley are low, averaging 6 feet per mile.

The extensive wetlands east and north of the 50 Fordham Road facility drain southeast to the Ipswich River and north to Martin's Brook, respectively. The apparent surface water divide in this area is expected to exist in the vicinity of the Stickney Well and the on-property WWTF. Drainage from the wetlands to the Ipswich River occurs through a culvert beneath Concord Street about 300 feet east of Hallberg Park (located approximately 3,200 feet east/southeast of the property).

Regional Water Budget

Rainfall records from the Town of Reading water pumping station at the 100-Acre Wellfield for the period 1880-1960 indicate an average annual rainfall of 41.15 inches (Sammel et al., 1966). Effective groundwater recharge at the 100-Acre Wellfield is estimated by Baker et al. (1964) at 11.7 inches annually based on stream flow records during periods of no rainfall. Evapotranspiration is estimated at 19.22 inches by Sammel et al. (1980), leaving 10.23 inches estimated as runoff. Similar recharge and evapotranspiration rates are expected to exist within the study area.

1.4 PREVIOUS RESPONSE ACTIONS

Several response actions have previously been conducted on the property and in the vicinity of the site. As described in the Phase II report (GZA, 1990) numerous underground storage tanks have been removed from the property. In June, 1987 General Electric Aerospace removed Tanks D, G, H and I (from the Tank Farm Area) and a small tank adjacent to Tank F (near the southwest corner of Building 1). Tank J (located east of Building 1A) was also removed in 1987. Tank F was removed in 1991. GE's sublessee, Converse, removed Tank K (east of Building 2) and Tank L (north of Building 2) prior to vacating the property in 1986.

To fulfill requirements of the Massachusetts DEP, two interim measures have been operated at the 50 Fordham Road property: 1) groundwater remediation in the Tank Farm Area, and 2) separate phase product (Stoddard solvent) recovery in the Eastern Parking Lot. These two measures are discussed briefly below.

The Tank Farm Area interim measures were approved by DEP and noted in their letter to GE Aerospace dated October 16, 1991. The Tank Farm Area remediation system consists of groundwater collection, treatment of volatile organic compounds (VOCs), and disposal. The system is currently operating and discharging treated effluent via Ametek

Storm Drain No. 1 to the wetlands. The system is located in a temporary building in the Tank Farm Area and start-up was initiated on February 28, 1992.

The groundwater is pumped from the recovery well TF-1, located in the building. A submersible pump is located in the well which operates on high and low level probe switches provided within the well to ensure adequate pump cycling. The groundwater is pumped through two bag filters in series (75 and 25 micron fabric filters, respectively) and granular activated carbon (GAC) units. Altogether, there are 9 GAC units in the building, each containing 330 lbs of coconut shell granular activated carbon, with only 3 GAC units in series at one time.

The effluent from the GAC system is discharged via Building 3 to Ametek's Storm Drain No. 1. The flow from the treatment system is monitored by a flow totalizer installed on the discharge pipe leaving the temporary building.

To date, the following approximate amounts have been recovered from the groundwater: 10.1 pounds of BTEX, 8.1 pounds of 1,2 dichloroethene and 4.6 pounds of vinyl chloride. In addition, approximately 190 gallons of separate phase Stoddard solvent has been recovered from the groundwater.

The Eastern Parking Lot Area Interim Measure was approved by DEP and noted in their letter to GE Aerospace dated December 19, 1991. The system was started up on March 20, 1992.

The recovery system consists of two recovery wells (one equipped with a belt skimmer and the other with a product pump) and a 240 gallon storage tank located in a temporary building. The belt skimmer includes a polyurethane belt which selectively attaches and retains hydrocarbons but repels water. The product pump contains sensors that sense the interface between water and product. An automatic level seek system moves the pumps up and down to track the water/product interface. To date, approximately 400 gallons of Stoddard solvent have been recovered from the two recovery wells in the Eastern Parking Lot.

Additional response actions include General Electric Aerospace reaching agreement with the Town of Reading in 1991 which provided funding for the Town to upgrade their water supply treatment system. This upgrading of the Town's water treatment plant was conducted to address groundwater contamination, the origin of which was unknown.

In 1991, General Electric Aerospace also reached agreement with the Town of North Reading related to the closure of the former Stickney Well in 1978. Under this agreement, General Electric Aerospace provided funding for the past and future replacement of water that the Town might otherwise have used.

1.5 RESULTS OF THE REMEDIAL INVESTIGATION

1.5.1 Hydrogeologic Properties of Overburden and Bedrock Strata

This discussion of hydrogeologic properties contains many of the typical sources of uncertainty in attempting to define hydrogeologic properties such as aquifer heterogeneity, temporal variations in groundwater, and interpretations based on widely spaced data points. The validity of the data is even more uncertain (particularly for off property areas where nearly all data is from other sources) due to the compilation of data from a variety of sources, different methods of data collection, and potential errors in data reduction or interpretation. Specific limitations for the following data presented include; hydraulic conductivity (aquifer heterogeneity, different test methods), transmissivity (assumes that estimates of hydraulic conductivity and aquifer thickness are accurate) and porosity (based on published values using sieve analysis or soil description by others).

1.5.1.1 Hydraulic Conductivity

Hydraulic conductivity (k) tests, in different strata at varying depths, have been conducted at on-property areas by GZA (1990) and Wehran (1991 and 1992). Measurements of k in the strata along Concord Street were conducted by GZA (1990). Rough estimates of k in the wetlands were reported by CDM (1986). Summaries of k values for on-property and off-property locations are provided in Tables 1-1 and 1-2. It should be noted that these tests were conducted using a variety of methodologies (slug tests, packer tests, and pump tests) and therefore the estimates of hydraulic conductivity should be considered approximations.

On-Property Area

Hydraulic conductivity (k) tests conducted on the property resulted in values which range over four orders of magnitude. This range reflects the variety of aquifer materials encountered. Hydraulic conductivity test results have been grouped into four sets

Table 1-1

MARTIN MARIETTA COPRORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF ON-PROPERTY HYDRAULIC CONDUCTIVITY VALUES[1]

Location	Hydraulic Conductivity [k] (ft/day)
Overburden Location	
PZ-1S	2.26
PZ-7S	4.66
PZ-8S	0.725
PZ-9S	2.61
GZA-101M	412
GZA-101D	197
GZA-104S	0.608
GZA-104D	69.1
GZA-106M	116
GZA-106D	91.0
GZA-107D	2.42
GZA-108S	87.4
GZA-108D	83.6
WE-1	10.5
WE-2	9.4
WE-3	9.8
WE-4S	4.2
WE-4D	5.4
WE-6	1.38

1 Hydraulic conductivity values taken from CDM (1986), GZA (1990), and Wehran (1991 and 1992).
2 All k values are for upper bedrock except for WE-105R2.

Table 1-1

MARTIN MARIETTA COPRORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF ON-PROPERTY HYDRAULIC CONDUCTIVITY VALUES[1]

Location	Hydraulic Conductivity [k] (ft/day)
Bedrock[2]	
GZA-101R	.433
GZA-102R1	2.39
GZA-103R1	0.001
GZA-104R1	1.124
GZA-105R	1.36
GZA-106R	1.061
GZA-107R	0.009
GZA-108R1	1.26
PZ-1R	0.012
PZ-2R	45.6
PZ-3R	6.805
PZ-4R	0.067
PZ-6R	0.100
PZ-8R	3.92
PZ-9R	0.045
DP-9	2.57
DP-10	6.71
WE-5R1	0.2
WE-6R	0.59

1 Hydraulic conductivity values taken from CDM (1986), GZA (1990), and Wehran (1991 and 1992).
2 All k values are for upper bedrock except for WE-105R2.

Table 1-1

MARTIN MARIETTA COPRORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF ON-PROPERTY HYDRAULIC CONDUCTIVITY VALUES[1]

Location	Hydraulic Conductivity [k] (ft/day)
WE-105R2	0.06

1 Hydraulic conductivity values taken from CDM (1986), GZA (1990), and Wehran (1991 and 1992).
2 All k values are for upper bedrock except for WE-105R2.

Table 1-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF ESTIMATED OFF-PROPERTY HYDRAULIC CONDUCTIVITY VALUES

Location	Hydraulic Conductivity (ft/day)
Overburden	
STM-1M	91.0
STM-2	2.83
STM-2D1	26.1
STM-3S	1.67
STM-3D	40.6
STM-6S	38.2
STM-6M	70.4
STM-8M	151.2
STM-8D	66.3
STM-9S	8.50
WETLANDS[3]	240

1 Hydraulic conductivity values taken from CDM (1986), GZA (1990), and Wehran (1991 and 1992).
2 All k values are for upper bedrock except for WE-105R2.
3 Deep overburden estimate (CDM, 1986).

Table 1-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF ESTIMATED OFF-PROPERTY HYDRAULIC CONDUCTIVITY VALUES

Location	Hydraulic Conductivity (ft/day)
Upper Bedrock	
STM-1R	1.27
STM-2R1	0.088
STM-3R	0.001
STM-4R	0.360
STM-5R	4.84
STM-6R1	0.103
STM-7R1	1.19
STM-8R	0.120
STM-9R	0.001
STM-10R1	0.117

1 Hydraulic conductivity values taken from CDM (1986), GZA (1990), and Wehran (1991 and 1992).
2 All k values are for upper bedrock except for WE-105R2.
3 Deep overburden estimate (CDM, 1986).

Table 1-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF ON-PROPERTY HORIZONTAL HYDRAULIC GRADIENTS(1)

Date	Shallow Overburden	Deep Overburden	Bedrock	Bedrock (Tank Farm)(2)
September 2, 3, 4, 1992*	0.0008	0.0012	0.0005	NC
October 12, 13, 14, 1992*	0.0008	0.0010	0.0008	0.053
November 17, 18, 19, 20, 1992	0.0009	0.0008	0.0014	0.024
December 30, 31, 1992	0.0013	0.0012	0.0017	0.1
January 21, 22, 1993	0.0013	0.0014	0.0018	0.1

(1) Average horizontal gradients estimated through middle portion of 50 Fordham Road property between eastern and western property boundaries.

(2) Average horizontal hydraulic gradients measured for bedrock within Tank Farm Area.

* Data obtained from second Supplemental Phase II Report (Wehran, December 1992).

NC Not calculated due to insufficient data.

representing various aquifer materials, including sand and gravel, sand, silty sand, and bedrock.

Hydraulic conductivity results for tests performed in the sand and gravel deposits (varying from sand, little gravel, little silt to sand and gravel) range from approximately 40 to 600 feet per day (ft/d). Test results for the sandy materials (varying from fine to medium sand) ranged from 2 to 120 ft/d. Test results for the silty sands produced values ranging from approximately 0.2 to 7 ft/d.

The hydraulic conductivity of the bedrock decreased with depth. The upper (1 to 10 feet) fractured zones of bedrock yielded results ranging from 0.01 to 50 ft/d. At depths of 10 to 20 feet into the bedrock, test results indicated more competent rock with k ranges of 0 to 0.5 ft/d.

Concord Street Area

GZA (1990) divided hydraulic conductivity and soil gradation test data from the piezometers along Concord Street into four groups of results; those representing values for sand and gravel, sand, till, and bedrock. Hydraulic conductivity values for the sand and gravel strata (ranging from sand, little gravel to gravel and sand) vary from approximately 2 to 150 ft/d. Values for tests performed in sandy strata (fine to coarse sand, trace to little silt) range from approximately 3 to 110 ft/d. One test performed in the till generated a value of 0.14 ft/d (several other tests performed within strata classified as till produced hydraulic conductivity estimates in the range of 60 to 70 ft/d, however, these tests were conducted in piezometers/wells which had screens that also intersected a more permeable layer overlying the till).

Hydraulic conductivity tests performed in bedrock core holes along Concord Street by GZA (1990) yielded values ranging from 0 to 10 ft/d. In general, k estimates based on these test results are low, in the range of 0.1 to 0.5 ft/d. These values indicate that neither the shallow or deep bedrock in this area is capable of transmitting significant quantities of water.

what are we [illegible]?

Wetlands Area

There have been a number of early investigations relating to the water supply development in the wetlands area. In 1958, CDM conducted seismic tests and exploratory wells in the Furbish Pond area (CDM, 1958). In an effort to measure changes in high iron concentrations (4.0 ppm) and to determine the probable safe yield of this potential water supply source, a three month-long pumping test was conducted in the vicinity of the Stickney Well area in 1963 (CDM, 1964).

The CDM (1986) report references a DEP estimate for the hydraulic conductivity of the sand and gravel deposits in the wetlands area of 200 ft/d based on results of the CDM pump test conducted in the vicinity of the Stickney Well in 1963 (CDM, 1964) and from initial records of the Stickney Well's operation (CDM, 1986). Wehran has not validated the accuracy of this data. Aquifer properties derived from various aquifer pumping tests in the Reading Town Forest area (D.L. Maher, 1982, 1985), where the saturated thickness of sediments is as great as 70 feet and transmissivities have been estimated at 10,000 to 15,000 feet squared per day (k = 143 to 214 ft/d).

The Stickney Well is located within the buried valley aquifer underlying the wetlands. The installed pumping capacity of the Stickney Well was 650,000 gpd (450 gpm) and the safe yield was estimated to be 540,000 gpd (375 gpm). (The well was constructed with an 18-inch diameter stainless steel casing inside a 24 inch gravel packed boring with ten feet of continuous slot screen installed to a depth of 52 feet.)

1.5.1.2 Transmissivity

Transmissivity estimates for on-property and off-property areas vary greatly due to significant variations in the saturated thickness and composition of overburden materials. In the area of shallow bedrock underlying the tank farm, for instance, a saturated thickness (excluding rock) of less than one to only several feet exists. In portions of the aquifer east of the property, with saturated thicknesses of nearly 65 feet, transmissivities of 10,000 to 13,000 feet squared per day (ft^2/d) can be expected. Saturated thickness and hydraulic conductivity estimates from the Concord Street area indicate transmissivity values for the overburden in this area ranging from zero (where the overburden is unsaturated) to nearly 4,000 ft^2/d in the bedrock valley under STM-3, (25 feet of saturated sand and gravel [excluding the less permeable till] with a hydraulic conductivity of approximately 150 ft/d).

Transmissivities in the on-property overburden deposits could be as high as 1,500 to 8,000 ft^2/d near the eastern property boundary where from 10 to 55 feet of sand and gravel may exist. Although borings along the property boundary were not advanced through all of the overburden, wells further to the east (in the wetlands) were advanced more than 70 feet below grade without encountering bedrock. In general, the overburden transmissivities in the central portion of the property, east of the buildings are expected to be in the range of 200 to 1,000 ft^2/d, based on hydraulic conductivity estimates discussed in the previous section and an approximate total saturated thicknesses of 20 to 30 feet.

The range of transmissivity values of the upper fractured portions of the bedrock in the study area is also expected to be highly variable, although considerably smaller in magnitude than that of the overburden deposits. Maximum bedrock transmissivities, based on a permeable fracture zone depth of 10 to 15 feet and a hydraulic conductivity estimate of 1 to 5 ft/d would range from 10 to 75 ft^2/d. In many areas, the transmissivity of the bedrock strata is negligible, as compared to the overlying deposits. However, localized fracture zones may represent substantial groundwater flow pathways.

1.5.1.3 Porosity

Porosities calculated from sieve analysis data of six samples obtained during the GZA (1990) study ranged from 0.20 for till samples to 0.43 for fine sand samples. Coarser sand and gravel samples had porosities ranging from 0.22 to 0.36. Based on these results, as well as typical values established for these soil types (Freeze and Cherry, 1979), the following average values were assigned to the different soil types tested:

- Glacial Till - 0.20
- Coarse Sand/Sand and Gravel - 0.25
- Fine Sand - 0.35

Average effective porosities assigned to the above soil types reflect a 25 to 75 percent reduction in the total porosity (Walton, 1970):

- Glacial Till - 0.15
- Coarse Sand/Sand and Gravel - 0.20
- Fine Sand - 0.20

1.5.1.4 Groundwater Flow Patterns

The following discussion on groundwater flow patterns is based on water level measurements collected by Wehran in January, March and April, 1993. The potentiometric data collected on January 21 and 22, 1993 have been plotted on Sheets 7, 8, and 9, respectively. (A summary of this data can be found in the Second Quarterly Monitoring Report prepared by Wehran in April 1993.) It is important to recognize that the data points shown in Sheets 7, 8, and 9 have been contoured for conceptual purposes only. The contours are approximate and based upon hydrogeologic interpretation subject to the following limitations:

1) monitoring points are widely spaced;
2) the set of individual data points is valid only for the 2-day window they were measured within; and
3) not all monitoring point elevations have been validated.

Actual conditions of groundwater flow patterns within the study area may vary from those shown in Sheets 7, 8, and 9.

The direction of groundwater flow beneath the property, in each of the three units shown (shallow and deep overburden deposits and bedrock), is similar and generally flows from the western boundary of the property to the east. This flow direction is consistent with previous measurements taken in September and October, 1992 as discussed in the Second Supplemental Phase II report.

The potentiometric data suggest that two apparent groundwater divides exist near the facility in the shallow overburden deposits, as shown in Sheet 7. (The presence or absence of these divides in the deep overburden materials and bedrock could not be determined due to the lack of data.) On the northern portion of the property, a groundwater divide appears to extend along a line between the treatment plant and the Stickney well area. Groundwater on the south side of this divide appears to be flowing in a southerly direction, whereas, groundwater on the opposite side appears to be flowing in a northerly direction. The other groundwater divide appears to be located to the south and southeast of the property, through the current Roadway and Coles Express facilities on Concord Street. An examination of the field measured potentiometric heads, the local flow conditions on the Roadway property, and the presence of a bedrock high in this area supports the occurrence of this divide. The axis of this inferred divide is approximately east-west, with groundwater apparently flowing south towards Concord Street and north towards the wetlands.

Approximately 10,000 gpd (7 gpm) of water is currently treated at the WWTF and discharged to groundwater through sand filter beds (Ametek, 1993). The GZA (1990) report states that a total of approximately 100,000 gpd (70 gpm) of non-contact cooling water, roof drainwater and parking lot runoff is discharged via outfalls 001 and 002.

Both on-property and off-property horizontal hydraulic gradients in the shallow and deep overburden, and in bedrock, are similar and average approximately 0.001. A summary of horizontal gradients across the property are presented in Table 1-3, and across the study area are tabulated in Table 1-4.

Vertical hydraulic gradients based on data collected by Wehran in March and April 1993 in on-property multilevel piezometers and wells are shown in Table 1-5. These values indicate predominantly downward vertical gradients ranging over most of the property. Greater downward vertical gradients are seen in the Tank Farm Area due to pumping from recovery well TF-1 (Sheet 9).

Table 1-6 lists vertical hydraulic gradients measured in off-property wells/piezometers for the March and April 1993 data. In the wetland area east of the property, predominantly upward gradients were measured within the overburden deposits ("PS" microwells). Along Concord Street ("STM" piezometers), most measurements revealed a downward gradient from the overburden into bedrock.

A review of the March and April, 1993 on-property and off-property vertical hydraulic gradient data gives an indication of the hydraulic relationship between the property and the adjacent wetlands. It appears that the vicinity of the Tank Farm Area is a groundwater recharge area. Closer to the wetlands, in the area of monitoring points GZA-106 and GZA-107, the vertical gradient between bedrock and deep overburden approaches zero, although there is still a downward gradient between the shallow and deep overburden deposits. Within the wetlands area, an upward gradient was measured during March and April, 1993 in individual well couplets screened in the deep to the shallow overburden. However, the analytical results from January 1993 indicate that chlorinated VOC concentrations remain higher in the deep overburden than shallow overburden.

Table 1-4

MARTIN MARIETTA CORPORATION WILMINGTON/NORTH READING, MASSACHUSETTS

REMEDIAL ACTION PLAN

SUMMARY OF REGIONAL HORIZONTAL HYDRAULIC GRADIENTS(1)

Date	Shallow Overburden	Deep Overburden	Bedrock
September 2, 3, 4, 1992*	0.0009	0.0009	0.0009
October 12, 13, 14, 1992*	0.0009	0.0009	0.0009
November 17, 18, 19, 20, 1992	0.0011	0.0011	0.0011
December 30, 31, 1992	0.0012	0.0012	0.0012
January 21, 22, 1993	0.0012	0.0012	0.0012

(1) Average horizontal gradients estimated through middle portion of 50 Fordham Road property from western property boundary, across wetlands, to STM-8.

* Data obtained from second Supplemental Phase II Report (Wehran, December 1992).

Table 1-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF ON-PROPERTY VERTICAL HYDRAULIC GRADIENTS

Monitoring Point Couplet	Monitoring Date	Groundwater Potentiometric Elevation (feet)	Vertical Distance* (feet)	Average Vertical Hydraulic Gradient	Apparent Vertical Flow Direction
GZA-102S and GZA-102R1	March 24, 1993 April 15, 1993	77.29/77.49 77.66/78.15	7.1 7.47	.0282 .0656	Upward Upward
GZA-103S and GZA-103R1	March 25, 1993 April 15, 1993	78.31/73.97 78.56/77.60	12.71 12.96	.3415 .0741	Downward Downward
GZA-104S and GZA-104R1	March 24, 1993 April 15, 1993	77.16/78.62 77.29/77.92	30.34 30.47	.0481 .0207	Upward Upward
GZA-105S and GZA-105R	March 25, 1993 April 14, 1993	77.38/77.27 77.39/77.42	30.08 30.09	.0037 .0010	Downward Upward
GZA-106S and GZA-106R	March 24, 1993 April 15, 1993	N/A / N/A 77.33/76.93	N/A 45.67	N/A .0088	N/A Downward
GZA-107S and GZA-107R	March 24, 1993 April 16, 1993	N/A / N/A 77.02/78.56	N/A 59.16	N/A .0260	N/A Upward
GZA-108S and GZA-108R	March 23, 1993 April 15, 1993	77.13/77.06 77.16/77.06	29.39 29.42	.0024 .0034	Downward Downward

* Vertical distance measured between water table elevation in shallow overburden and top of screened interval in bedrock of piezometer/well couplets screened in shallow overburden and bedrock.

Note: Measurements assume a groundwater hydraulic connection between the shallow overburden materials and bedrock.

N/A Information not available

Table 1-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF ON-PROPERTY VERTICAL HYDRAULIC GRADIENTS

Monitoring Point Couplet	Monitoring Date	Groundwater Potentiometric Elevation (feet)	Vertical Distance* (feet)	Average Vertical Hydraulic Gradient	Apparent Vertical Flow Direction
PZ-1S and PZ-1R	March 24, 1993 April 15, 1993	N/A / N/A 81.99/80.08	N/A 33.8	N/A .0565	N/A Downward
PZ-4S and PZ-4R	March 25, 1993 April 15, 1993	N/A / N/A 78.33/77.87	N/A 36.71	N/A .0125	N/A Downward
PZ-6S and PZ-6R	March 24, 1993 April 15, 1993	77.44/76.66 77.76/77.16	46.39 46.71	.0168 .0128	Downward Downward
PZ-7S and PZ-7R	March 24, 1993 April 14, 1993	77.59/77.47 N/A / N/A	31.80 N/A	.0038 N/A	Downward N/A
PZ-9S and PZ-9R	March 25, 1993 April 15, 1993	78.30/77.93 78.29/78.12	34.03 34.02	.0109 .0050	Downward Downward
WE-6 and WE-6R	March 24, 1993 April 15, 1993	N/A / N/A 78.44/78.25	N/A —	N/A —	N/A Downward

* Vertical distance measured between water table elevation in shallow overburden and top of screened interval in bedrock of piezometer/well couplets screened in shallow overburden and bedrock.

Note: Measurements assume a groundwater hydraulic connection between the shallow overburden materials and bedrock.

N/A Information not available

Table 1-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF OFF-PROPERTY VERTICAL HYDRAULIC GRADIENTS

Monitoring Point Couplet	Monitoring Date	Groundwater Potentiometric Elevation (feet)	Vertical Distance* (feet)	Average Vertical Hydraulic Gradient	Apparent Vertical Flow Direction
PS-1S and PS-1D	March 23, 1993 April 16, 1993	76.30/ N/A 76.02/76.04	48.91 48.63	N/A .0004	N/A Upward
PS-2S and PS-2D	March 23, 1993 April 16, 1993	75.87/76.04 75.53/75.82	47.99 47.65	.0035 .0061	Upward Upward
PS-5S and PS-5D	March 23, 1993 April 16, 1993	75.76/75.78 75.25/75.43	20.15 19.64	.0010 .0092	Upward Upward
PS-7S and PS-7D	March 23, 1993 April 16, 1993	76.27/76.02 75.99/76.31	45.61 45.33	.0055 .0071	Downward Upward
PS-8S and PS-8D	March 23, 1993 April 16, 1993	76.22/76.37 76.05/76.21	45.31 45.14	.0033 .0036	Upward Upward
STM-1S and STM-1R	March 25, 1993 April 16, 1993	76.25/76.15 76.32/76.17	39.69 39.76	.0025 .0038	Downward Downward
STM-2S and STM-2R1	March 25, 1993 April 16, 1993	N/A / N/A 75.51/74.10	N/A 80.54	N/A .0175	N/A Downward

* Vertical distance measured between water table elevation in shallow overburden and top of screened interval in bedrock of piezometer/well couplets screened in shallow overburden and bedrock.

Note: Measurements assume a groundwater hydraulic connection between the shallow overburden materials and bedrock.

N/A Information not available

Table 1-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF OFF-PROPERTY VERTICAL HYDRAULIC GRADIENTS

Monitoring Point Couplet	Monitoring Date	Groundwater Potentiometric Elevation (feet)	Vertical Distance* (feet)	Average Vertical Hydraulic Gradient	Apparent Vertical Flow Direction
STM-3S and STM-3R	March 25, 1993 April 16, 1993	74.01/73.99 74.12/74.07	58.01 58.12	.0004 .0009	Downward Downward
STM-4S and STM-4R	March 25, 1993 April 16, 1993	N/A /75.75 76.41/75.72	N/A 9.63	N/A .0717	N/A Downward
STM-5S and STM-5R	March 25, 1993 April 16, 1993	75.33/75.22 75.18/75.37	11.23 11.08	.0098 .0171	Downward Upward
STM-6S and STM-6R1	March 25, 1993 April 16, 1993	77.81/75.43 77.47/75.43	31.65 31.31	.0752 .0652	Downward Downward
STM-7S and STM-7R1	March 25, 1993 April 16, 1993	78.90/78.28 78.89/78.26	9.36 9.35	.0662 .0674	Downward Downward
STM-8S and STM-8R	March 25, 1993 April 16, 1993	74.89/74.52 75.07/74.48	42.56 42.74	.0087 .0138	Downward Downward
STM-9S and STM-9R	March 25, 1993 April 16, 1993	N/A / N/A N/A /75.87	N/A N/A	N/A N/A	N/A N/A

* Vertical distance measured between water table elevation in shallow overburden and top of screened interval in bedrock of piezometer/well couplets screened in shallow overburden and bedrock.

Note: Measurements assume a groundwater hydraulic connection between the shallow overburden materials and bedrock.

N/A Information not available

Table 1-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF OFF-PROPERTY VERTICAL HYDRAULIC GRADIENTS

Monitoring Point Couplet	Monitoring Date	Groundwater Potentiometric Elevation (feet)	Vertical Distance* (feet)	Average Vertical Hydraulic Gradient	Apparent Vertical Flow Direction
STM-10S and STM-10R1	March 25, 1993	76.08/75.93	6.77	.0222	Downward
	April 16, 1993	76.24/76.02	6.93	.0317	Downward

* Vertical distance measured between water table elevation in shallow overburden and top of screened interval in bedrock of piezometer/well couplets screened in shallow overburden and bedrock.

Note: Measurements assume a groundwater hydraulic connection between the shallow overburden materials and bedrock.

N/A Information not available

1.5.1.5 Groundwater Flow Rates

Groundwater seepage velocity is calculated based on the hydraulic conductivity of the aquifer, the hydraulic gradient within that aquifer, and the effective porosity. The rate is given by (Bear, 1979):

$$V = Ki/n_e$$

where

V = seepage (linear or pore) velocity (ft/d)

K = hydraulic conductivity (ft/d)

i = hydraulic gradient (ft of water per ft)

n_e = effective porosity

Estimates of groundwater flow through various portions of the 50 Fordham Road property have been made for each of the three potential source areas: 1) the Tank Farm Area, 2) the Eastern Parking Lot Area, and 3) the Tank K Area.

Based on an estimated horizontal hydraulic gradient of 0.001 (under non-pumping conditions) an estimated hydraulic conductivity of 100 ft/d and an effective porosity of 0.20, the overburden seepage velocity from the Tank Farm area is conservatively estimated at 0.5 ft/d.

Seepage velocity estimates for groundwater flow through the Tank K Area overburden materials range from 0.02 to 0.06 ft/d. These calculations were based on field measured hydraulic conductivities ranging from 4 to 12 ft/d, a horizontal hydraulic gradient of 0.001 and an estimated effective porosity of 0.20.

Based on a hydraulic gradient of 0.001, effective porosity of 0.20 and hydraulic conductivity ranging from 50 to 150 ft/d, the seepage velocity for the overburden materials (gravelly sand) in the Eastern Parking Lot Area is estimated to vary from 0.25 to 0.75 ft/d.

Based on the DEP estimate for an average hydraulic conductivity of 200 ft/day for the wetlands aquifer east of the property (CDM, 1986), an average effective porosity of 0.20, and an average hydraulic gradient of 0.001, the seepage velocity for the deep overburden in the wetlands area is calculated to be approximately 1.0 ft/d.

1.5.2 Distribution of Oil and Hazardous Materials

1.5.2.1 Overview

This section describes the distribution of the oil and hazardous materials in soils, sediment, and groundwater on the property based on data collected during investigations conducted by CDM (1986), GZA (1990), and Wehran (1991, 1992, and 1993).

There are four major areas impacted by contamination on the property. These include the Tank Farm Area, the Tank K Area, and the Eastern Parking Lot Area, and the Outfall 001 Drainage Ditch Area. Analytical data have shown that four primary types of organic compounds exist on the property. These include chlorinated volatile organic compounds (Cl-VOC), total petroleum hydrocarbons (TPH), BTEX compounds (sum of benzene, toluene, ethylbenzene and xylene isomers), and light non-aqueous phase liquid (LNAPL) identified as Stoddard solvent and gasoline. The distribution of these types of organic compounds can be summarized as follows:

- Tank Farm Area
  - Cl-VOCs
  - LNAPL identified as Stoddard solvent
  - Stoddard solvent-related BTEX compounds
  - TPH
- Eastern Parking Lot
  - Cl-VOCs
  - LNAPL identified as Stoddard solvent
  - Stoddard solvent-related BTEX compounds
  - TPH
- Outfall 001
  - TPH (at much lower concentrations than Eastern Parking Lot)
- Tank K
  - LNAPL identified as gasoline
  - Gasoline-related BTEX compounds

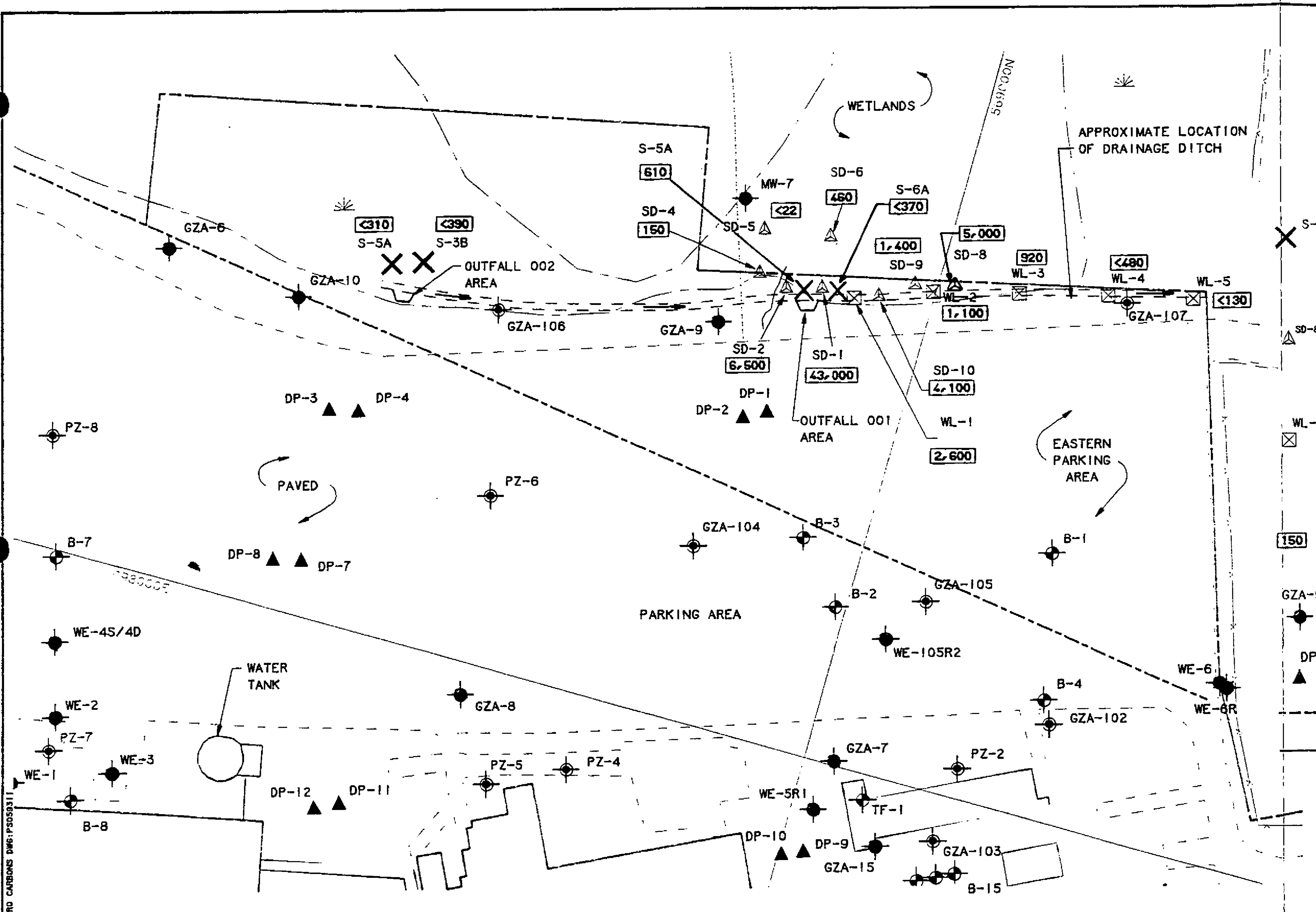
The type and approximate extent of contamination in these on-property areas have been plotted on Sheets 10 to 15. The contouring of contaminant concentrations depicted on these sheets represent interpretations based on data from widely spaced borings, monitoring wells, and soil gas points. The actual extent and concentration of contaminants may vary from those shown. Dissolved VOCs in groundwater are shown in Sheets 10 through 13. LNAPL locations and TPH concentrations in unsaturated soils are presented in Sheet 14 and the approximate extent of VOCs in unsaturated soils is given in Sheet 15. Figures 1-2 and 1-3 provide cross-sectional views of the approximate distribution of dissolved VOCs and TPH on the property while Figure 1-4 presents the results of TPH sediment sampling in the Outfall 001/Drainage Ditch Area.

1.5.2.2 Tank Farm Area/Eastern Parking Lot Area

The Tank Farm and Eastern Parking Lot Areas appear to have been impacted by four different contaminant types including chlorinated VOCs (Cl-VOCs), LNAPL identified as Stoddard solvent, Stoddard solvent-related BTEX compounds, and TPH. Sheets 10 and 11 are plan views of Cl-VOCs detected in groundwater in overburden and bedrock, respectively, during the January 1993 sampling round conducted by Wehran (1993). Sheets 12 and 13 show concentrations of BTEX compounds in overburden and bedrock groundwater, respectively, for the same sampling round.

Using data compiled by GZA (1990), Figures 1-2 and 1-3 illustrate hydrogeologic cross-sections through the Tank Farm and Eastern Parking Lot Areas with estimated isoconcentration lines for Cl-VOCs and Stoddard solvent-related BTEX compounds, respectively. The data illustrated on these maps indicate that the Tank Farm may be the source of contaminant releases to groundwater in both the Tank Farm Area and Eastern Parking Lot. In contrast, the presence of gasoline-related BTEX compounds detected in the Tank K Area appears to be caused by the former Tank K underground gasoline storage tank.

As discussed in the GZA Phase II report, exposed bedrock in the Tank Farm Area may have been removed to allow installation of the tanks. Prior to and during the first 12 to 15 months of operation of recovery well TF-1, the highest concentrations of Cl-VOCs were observed in groundwater from GZA-103R1, which is screened in the upper bedrock zone (Figure 1-2). The latest sampling rounds (in January and April 1993) indicate that concentrations of total Cl-VOCs were observed to decrease in GZA-103R1 from a high of 60,000 ppb in August 1992 to approximately 3,000 ppb. Monitoring well WE-5R1 is located approximately 100 feet north of TF-1 and is screened in the upper bedrock zone (13-28 feet bgs). As shown in Sheet 11, samples collected from this well in January 1993 indicate



LEGEND:

S-5A — SEDIMENT SAMPLING LOCATION-SAMPLES COLLECTED FROM OUTFALL AREAS BY WEHRAN IN SEPTEMBER, 1991. RESULTS SUMMARIZED IN "PHASE II INVESTIGATION" PREPARED BY WEHRAN IN NOVEMBER, 1991.

SD-8 — SEDIMENT SAMPLING LOCATION-SAMPLES COLLECTED FROM OUTFALL AREAS BY WEHRAN IN SEPTEMBER, 1991. RESULTS SUMMARIZED IN "PHASE II INVESTIGATION" PREPARED BY WEHRAN IN NOVEMBER, 1991.

WL-1 — SEDIMENT SAMPLING LOCATION, SAMPLES COLLECTED ROM OUTFALL AREAS BY WEHRAN IN SEPTEMBER, 1992. RESULTS SUMMARIZED IN "SECOND SUPPLEMENTAL PHASE II INVESTIGATION" PREPARED BY WEHRAN IN DECEMBER, 1992.

150 — SEDIMENT TPH CONCENTRATION IN mg/kg (ppm). < = LESS THAN THE DETECTION LIMIT ALL SEDIMENT SAMPLES ANALYZED FOR TPH USING USEPA METHOD 418.1

GZA-9 — MONITORING WELLS INSTALLED BY GZA DRILLING, INC. FROM NOVEMBER, 1986 TO MAY, 1987.

DP-1 — DRAINLINE PIEZOMETER INSTALLED BY GZA DRILLING, INC. IN JULY, 1989.

PROPERTY LINE

GENERAL DIRECTION OF SURFACE WATER FLOW

0 80

SCALE, IN FEET

NOTES:

1. BASE MAP PROVIDED TO WEHRAN ENGINEERING BY AUTOMATED COMPLIANCE SYSTEMS, INC. (ACS) BRIDGEWATER, NJ. ACS MAP DEVELOPED FROM PLAN PROVIDED BY GENERAL ELECTRIC COMPANY ENTITLED "SITE PLAN", UNDATED, ORIGINAL SCALE: 1" = 40'.

2. THE LOCATIONS OF MONITORING WELLS INSTALLED BY GZA AND BY GUILD DRILLING WERE DETERMINED BY SURVEY PERFORMED BY DANA F. PERKINS & ASSOC., INC.

FIGURE 1-4

TPH IN OUTFALL/DRAINAGE DITCH SEDIMENTS

MARTIN MARIETTA CORPORATION
WILMINGTON/N. READING, MASSACHUSETTS

WehranEnviroTech

C1-VOC concentrations of 60,100 whereas in the same well in April, the concentration decreased to 27,000 ppb

The cross-sectional map of total Stoddard solvent-related BTEX isoconcentration lines beneath the property (Figure 1-3) indicate that one of the two most concentrated areas of Stoddard solvent-related BTEX compounds was originally identified by GZA in 1989 to be in the vicinity of GZA-103R1. Concentrations of Stoddard solvent-related BTEX compounds were observed to decrease between monitoring points GZA-103R1 and GZA-103R2 at that time. During the January 1993 sampling round, the Stoddard solvent-related BTEX concentrations also appeared to decrease with depth into the bedrock.

In general, concentrations of the Cl-VOCs and Stoddard solvent-related BTEX compounds in groundwater appear to decrease significantly outward from the Tank Farm Area in both overburden and bedrock groundwater (Sheets 10, 11, 12, and 13). To the east of the Tank Farm Area, Cl-VOCs have been detected in the Eastern Parking Lot area. Cl-VOCs also have been detected in the Wetlands Area, at significantly lower concentration. Dissolved Stoddard solvent-related BTEX compounds have not been detected in overburden or bedrock wells located along the eastern edge of the parking lot (Sheets 12 and 13).

TPH compounds were detected in unsaturated overburden deposits in the Tank Farm and Eastern Parking Lot Areas and have been identified by TPH fingerprint analyses to consist primarily of Stoddard solvent. Stoddard solvent is similar in composition and properties to mineral spirits and has been historically used at the facility as a surrogate for jet fuel during engine testing operations. Results of field observations and analysis of a liquid sample collected at shallow overburden monitoring well GZA-105S indicated that a light non-aqueous phase liquid (LNAPL) identified as separate phase Stoddard solvent was present in this well. Sheet 14 shows the locations of two other shallow overburden monitoring wells, PZ-2S and DP-6 which contained measurable quantities of LNAPL during the last monitoring event conducted on April 15, 1993, by Wehran. Approximately one-half foot of LNAPL was observed above the water table in PZ-2S and in DP-6, whereas approximately 0.01 feet was observed in GZA-105S.

separate phase Stoddard solvent found in these wells.

Concentrations of VOCs (based on headspace screening and laboratory analytical results) in samples collected from unsaturated soils in the Tank Farm/Eastern Parking Lot Areas generally were significantly lower than results from saturated samples (Sheet 15).

The presence of VOCs in unsaturated media appears to correlate closely with those areas containing relatively high concentrations of VOCs in the saturated zone.

1.5.2.3 Tank K Area

Results in the Tank K Area indicate that unsaturated soil and saturated soil have been impacted by gasoline-related BTEX compounds likely releases in the area of the former gasoline underground storage Tank K. LNAPL (gasoline) was observed in monitoring well WE-2 (apparent thickness of 0.01 foot) during the most recent groundwater monitoring conducted on April 15, 1993 by Wehran. As indicated in Sheet 12, overburden groundwater and saturated soils appear to have been impacted in a relatively limited area between the former Tank K location and between WE-4S/4D and B-7.

Elevated concentrations of gasoline-related BTEX were detected in groundwater from on-property wells in the Tank K Area during the January, 1993 sampling event and ranged from 9.4 ppb in WE-4D to 42,600 ppb in PZ-7S. The total gasoline-related BTEX content in groundwater from bedrock well PZ-7R has steadily increased from a concentration of 135-155 ppb in August of 1989 (measured by GZA), to a concentration of 3,920 ppb in August/September 1992 to 13,300 ppb in January 1993. Historically, the extent of contamination in the Tank K area has been limited to groundwater within the shallow overburden deposits. Therefore, Wehran believes the detection of gasoline-related BTEX compounds in the bedrock piezometer was caused by a crack in the piezometer casing, allowing gasoline-related BTEX compounds to enter the well from the shallow overburden. (This piezometer cluster was decommissioned in April 1993 and a new bedrock well is proposed for installation during June/July 1993.) The extent of gasoline-related BTEX contamination in bedrock in the Tank K Area is therefore assumed to be very localized and is not expected to require remedial action.

The approximate extent of gasoline-related BTEX in the unsaturated soil at the Tank K Area (Sheet 15) coincides closely to that of dissolved gasoline-related BTEX in the shallow groundwater zone (Sheet 12).

1.5.2.4 Outfall 001/Drainage

Analytical data collected during investigations by Wehran (1991 and 1992) and GZA (1990) indicate that sediment near Outfall 001 and the drainage ditch has been impacted by TPH compounds. Although the extent of sediment impacted by TPHs adjacent to Outfall 001 has not been completely defined (additional sampling will be conducted in June/July 1993), the concentrations of these compounds appear to decrease significantly just beyond the outfall.

1.5.2.5 Wetlands Area

Total Cl-VOC concentrations in groundwater from the four overburden wetland locations sampled during the January 1993 sampling round (Wehran 1993) are shown on Sheet 10. The levels of Cl-VOC concentrations in samples collected from the multi-level microwells, PS-1, PS-2, PS-4, and PS-5 ranged from 6 ppb in PS-2S to 355 ppb in PS-1D. Previous analyses by ABB Environmental Services, Inc. in April, 1992 showed nearly identical results for samples collected from multi-level microwell clusters PS-1, PS-2 and PS-5.

1.5.2.6 Tank F Area

During the Wehran Supplemental Phase II Investigation in 1991, results of headspace screening conducted on overburden soil samples collected from this area did not indicate the presence of significant VOC contamination. Prior groundwater analytical results from GZA-101 indicated that concentrations of chlorinated hydrocarbons increased significantly between overburden and bedrock groundwater. Based upon observations and screening results during removal of Tank F, overburden VOC contamination was not evident in this area. Therefore, it is possible that the relatively low concentrations of chlorinated hydrocarbons reported in overburden groundwater samples from GZA-101S (29 ug/l), GZA-101M (13 ug/l), and GZA-101D (213 ug/l), may be due to diffusion from the underlying, fractured bedrock in which higher concentrations of chlorinated hydrocarbons were reported in 1989 in groundwater from GZA-101R (4,976 ug/l). (Subsequent sampling of this well has detected significantly lower concentrations of chlorinated hydrocarbons ranging from 105 to 2,350 μg/l.) These concentrations in GZA-101R cannot be explained based upon the east-northeast bedrock groundwater flow directions previously reported during the GZA Phase II investigation. If correct, the bedrock groundwater flow direction reported may indicate an upgradient source of these chlorinated hydrocarbons approximately west of Tank F. Alternatively, this bedrock groundwater quality could be due to local anomalies in groundwater flow.

2.0 REMEDIAL OBJECTIVES AND CLEANUP LEVELS

The risk characterization conducted by Arthur D. Little (1991) for the 50 Fordham Road site concluded that remedial actions are required at the site. The purpose of this Phase III Remedial Action Plan is to identify and select an alterative that will address the potential risks identified, and that will be a permanent solution if one is feasible. As a basis for alternative identification and selection, this section of the report develops remedial objectives and cleanup levels. These remedial objectives and cleanup levels will be used in the evaluation of all remedial action alternatives. The Massachusetts Contingency Plan (MCP) at 310 CMR 40.0850 states that "a Phase III Evaluation shall result in the selection of a remedial action alternative which is a likely Permanent Solution..." (will likely achieve a level of No Significant Risk) if one is feasible. The MCP also states that a recommended alternative that is a permanent solution include "measures that reduce, to the extent feasible, the concentration of oil and hazardous material in the environment to levels that achieve or approach background". The remedial objectives and cleanup levels provided here, when achieved, would result in a level of No Significant Risk and would be a Permanent Solution.

Prior to the establishment of the remedial objectives, a summary of the Phase II Risk Characterization is presented in Section 2.1 (Risk Assessment Summary) to review potential exposure routes and receptors of concern, and total site cancer and non-cancer risks. It should be noted that this risk characterization and all of the Phase II activities were completed before promulgation of the July 1993 revisions to the MCP. The development of remedial objectives is presented in Section 2.2, and the development of site cleanup levels is presented in Section 2.3. These sections were prepared in accordance with the revised MCP, 310 CMR 40.0800, 40.0900, and 40.0100.

2.1 RISK ASSESSMENT SUMMARY

A revised risk assessment was completed for the site as part of the Phase II Comprehensive Site Assessment by Arthur D. Little (ADL) in December, 1991. The report supplemented and revised the public health and ecological risk characterization prepared by Goldberg-Zoino & Associates (GZA 1990).

The purpose of the risk assessment was to provide an assessment of the potential public health and ecological risks and compare them to regulatory risk standards, in order to determine whether remediation was required. This evaluation was based on human and environmental exposures that may result from the site's current use and condition, as well as any reasonably foreseeable use. Included in this section is a summary of the revised Phase II Risk Assessment (ADL 1991). The reader should refer to the actual report for a complete discussion of the risk assessment.

2.1.1 Exposure Assessment Summary

The receptor groups evaluated in the risk assessment include current facility workers who use the property on a daily basis, utility workers who may be potentially exposed to contaminants for short periods of time during the repair of buried utility lines, and, as requested by DEP, residents (both adults and children) of Reading and North Reading who may be exposed through ingestion of water from a hypothetical future water supply well in the area of the former Stickney well and from the existing Town of Reading water supply wells. Table 2-1 (ADL 1991) is included to summarize the exposure routes and pathways evaluated for these receptor groups.

Exposure point concentrations were developed by ADL (from measured and estimated concentrations) as the basis for characterizing potential risks. Estimation of vapor exposures (i.e. in normal breathing spaces, excavations, and from surface water) were based upon soil gas measurements from the potential source areas and mathematical models. Concentrations in the hypothetical North Reading well and the Reading supply wells were also estimated, based upon solute transport calculations. Measured exposure point concentrations consisted of arithmetic means of the detected chemical concentrations.

2.1.2 Public Health Risk Characterization Summary

Table 2-2 (ADL 1991) summarizes the hazard indices (non-cancer effects) and excess lifetime carcinogenic risk estimates (cancer effects) for the receptor groups identified at the site.

Noncarcinogenic Effects

The MCP (310 CMR 40.545 (3)(g) required that at multi-media disposal sites, one or more Hazard Indices be used to evaluate non-carcinogenic health risks. In order to determine the need for remediation, Hazard Index values were compared to total site non-cancer risk limits, which was a Hazard Index equal to 0.2. It should be noted that this regulatory risk limit has changed to one (1) in the revised MCP (310 CMR 40.0993(6)).

As shown in Table 2-2, both the subchronic and chronic Hazard Indices calculated for the utility workers at all exposure point locations, except for the former tank F area, exceeded the regulatory risk limit of 0.2. The exposure pathway which contributed the most significantly to the utility workers exposure was the inhalation of vapors during excavations, as estimated using soil gas measurements. It should be noted that all of the hazard indices associated with these subchronic exposures also exceeded the revised regulatory limit of one. Thus, the conclusions of the ADL risk assessment would not change as a result of the new regulations.

Carcinogenic Effects

The MCP (310 CMR 40.545 (3)(g) required that the "total site cancer risk" be used to evaluate carcinogenic health risks at multi-media disposal sites. In determining the need for remediation, the "total site cancer risk" was compared to the "total site cancer risk limit" which was an excess lifetime cancer risk of one-in-one hundred thousand (1×10^{-5}).

Table 2-2 shows that the estimated total site cancer risks for the residents of North Reading and Reading ingesting untreated groundwater from the hypothetical North Reading well and the Reading water supply wells, respectively, would exceed the total site cancer risk limit, based upon the estimated concentrations at those wells. Exposure (based upon inhalation of vapors while excavating trenches) for the utility workers in the former tank farm area and nearby drum storage areas, and former tank K area also exceeded the total site cancer risk limit.

2.1.3 Ecological Risk Characterization Summary

A screening level ecological risk characterization was performed by ADL to evaluate the potential risks from the site to organisms, aquatic habitats and ecosystem function, based upon current and reasonably foreseeable future uses of the wetland north of Concord

Street. For the purposes of the assessment, the study area was defined as the vegetated wetland area immediately adjacent to the property, including the drainage ditch along the employee parking lot.

The screening risk characterization was performed by identifying the site ecosystems, presenting the chemical concentrations detected in surface water and sediment, and reviewing the ecotoxicological effects of compounds present for the particular organisms at risk. The numerical selection criteria used to identify compounds of potential concern include the following; EPA Ambient Water Quality Criteria (AWQC), aquatic indices based upon the Lowest Observed Effects Level (LOEL) reported in the literature for both acute and chronic exposure, terrestrial indices based on LOEL for both acute and chronic exposure, and National Oceanic and Atmospheric Administration (NOAA) 1990 Sediment Guidelines.

ADL concluded that the low levels of metals and VOCs detected in the wetlands samples were of no ecological concern. They also concluded that sediment concentrations of several metals in the drainage ditch could pose a risk to some species that may inhabit this location, but would not pose a significant risk to the larger wetland ecosystem. In addition, ADL concluded that sediment concentrations of metals, phthalates and total petroleum hydrocarbons (TPH) in the outfall basins could pose ecological risks in localized areas, but would not pose a risk to the wetlands. A literature search subsequently conducted by Wehran (1992) concluded that elevated metals concentrations (as compared to typical background concentrations) are restricted to fill in the drainage ditch and adjacent upland areas. Elevated metals concentrations were not identified in the wetlands sediment to the east of the facility.

2.2 DEVELOPMENT OF REMEDIAL OBJECTIVES

Wehran developed remedial action goals for the site to address the potential risks to public health and the environment identified in the risk assessment (ADL 1990). The remedial action goals presented in Table 2-3 indicate the types and locations of exposures to be addressed by the remedial action alternatives, based on the conclusions of the risk assessment. In addition, the elimination of LNAPL is identified as a remedial action goal because a permanent solution cannot be achieved without elimination of active sources, including LNAPL (310 CMR 40.1003).

Table 2-3 also provides remedial action objectives and potential actions that correspond to each remedial goal. These objectives provide specific risk reduction approaches that could be incorporated into the remedial action alternatives. In the case of public health risks, the objectives include either a reduction in exposure point concentrations, or an elimination of exposure. Specific mechanisms proposed to eliminate exposure will be evaluated in subsequent sections with respect to their potential to meet the MCP goal of "permanency".

One way of meeting the remedial action objectives, or a level of No Significant Risk for the site, is through the use of DEP Method 1 standards. The Method 1 standards were developed as part of the revisions to the MCP (40.0900) to characterize potential risks at a site through the use of promulgated standards (referred to as Method 1 standards). The achievement of these standards at a site would indicate that the site no longer poses a significant risk to health, public welfare and the environment.

Categories of groundwater (GW-1, GW-2 and GW-3) and soil (S-1, S-2 and S-3) have been established by the DEP for use in characterizing the potential risks through this method. The criteria for classifying groundwater or soil in the appropriate category are based upon the potential for exposure. The cleanup levels for the 50 Fordham Road site are based upon Method 1 standards, considering the appropriate groundwater and soil categories, described in the next section.

2.3 DEVELOPMENT OF CLEANUP LEVELS

The previous section indicated that contaminant concentration reduction is one method of achieving remedial goals and objectives established for the site. In the event that contaminant concentration reduction is selected as the remedial action, Method 1 cleanup standards are proposed as cleanup levels. In most cases, contaminant concentration reduction is the only potential action that will meet the remedial objectives. In the case of soils, however, an activity and use limitation to prevent exposure to contaminated soils could theoretically be considered as an alternative to contaminant concentration reduction.

Table 2-1
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
PHASE III FEASIBILITY STUDY

SUMMARY OF EXPOSURE PROFILES FOR THE PUBLIC HEALTH RISK ASSESSMENT

RECEPTORS:	SOURCE AREAS: FORMER TANK FARM	FORMER TANK K	FORMER TANK F	EMPLOYEE PARKING LOT	STORM WATER OUTFALLS	DRINAGE DITCH ADJ. WETLANDS	TOWN WATER SUPPLIES READING OR	TOWN WATER SUPPLIES NORTH READING
FACILITY WORKER	Inhalation	Inhalation	Inhalation	NP	Dermal Contact - Soil Ingestion - Soil inhalation	NP	Ingestion - Water Dermal Contact - Water Inhalation	Ingestion - Water Dermal Contact - Water Inhalation
UTILITY WORKER	Inhalation Dermal Contact - Soil Dermal Contact - Water Ingestion - Soil Ingestion - Water	Inhalation Dermal Contact - Soil Dermal Contact - Water Ingestion - Soil Ingestion - Water	Inhalation Dermal Contact - Soil Ingestion - Soil	Inhalation Dermal Contact - Soil Dermal Contact - Water Ingestion - Soil Ingestion - Water	NP	NP	Ingestion - Water Dermal Contact - Water Inhalation	Ingestion - Water Dermal Contact - Water Inhalation
READING RESIDENTS	NP	NP	NP	NP	NP	NP	Ingestion - Water Dermal Contact - Water Inhalation	NP
NORTH READING RESIDENTS	NP	NP	NP	NP	NP	NP	NP	Ingestion - Water Dermal Contact - Water Inhalation
NORTH READING CHILD	NP	NP	NP	NP	NP	Inhalation Dermal Contact - Soil Dermal Contact - Water	NP	NP ?

NP - not a pathway

Table taken from Arthur D. Little, Inc. Report entitled 'Public Health and Ecological Risk Characterization for 30 Fordham Road Property, Wilmington/North Reading, Massachusetts' dated December 13, 1991.

Table 2-2
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
PHASE III FEASIBILITY STUDY

PUBLIC HEALTH RISK CHARACTERIZATION SUMMARY

PATHWAY	SUBCHRONIC HI	CHRONIC HI	CARCINOGENIC RISK
NORTH READING DRINKING WATER RISKS			
Due to Tank K			
Adult	4E 03	1E 02	3E 06
Child	4E-03	1E 02	1E 06
Due to Tank Farm			
Adult	5E 03	2E 02	3E 04
Child	4E-08	4E 02	1E 04
Total Effect			
Adult	9E-03	5E-02	4E-04
Child	9E-03	5E-02	2E-04
READING DRINKING WATER RISKS			
Due to Tank K			
Adult	9E-04	2E 03	7E-07
Child	9E-04	2E-03	2E-07
Due to Tank Farm			
Adult	9E-04	9E-03	9E-05
Child	9E-04	9E-03	3E-05
Total Effect			
Adult	1E-03	1E-02	9E-05
Child	1E-03	1E-02	3E-05
CHILD IN DRAINAGE DITCH AND WETLAND			
Inhalation	1E-02	9E-04	4E-07
Contact with soil	1E-02	1E-03	5E-07
Contact with water	1E 02	1E-03	3E-06
Incidental soil ingestion	4E-02	4E 03	1E-07
Incidental water ingestion	8E-03	6E-04	6E-09
Total:	8E-02	8E-03	4E-06

NA = Cancer Potency Factor not currently listed in literature

PATHWAY	SUBCHRONIC HI	CHRONIC HI	CARCINOGENIC RISK
UTILITY WORKER - TANK F			
Inhalation	2E-01	3E 03	1E 07
Contact with soil	3E-06	3E-07	4E-13
Incidental soil ingestion	3E 07	4E 08	6E-14
Total:	2E-01	3E-03	1E-07
UTILITY WORKER - TANK FARM			
Inhalation	2E+01	3E-01	5E-06
Contact with soil	5E-05	2E 05	NA
Contact with water	2E 01	5E-02	8E-06
Incidental soil ingestion	6E-08	2E-08	NA
Incidental water ingestion	2E-04	6E-05	2E 09
Total:	2E+01	3E-01	1E-05
UTILITY WORKER - PARKING LOT			
Inhalation	1E+01	1E 01	6E-07
Contact with soil	2E-08	6E-05	NA
Contact with water	2E-02	2E-03	1E-07
Incidental soil ingestion	2E-07	8E-06	NA
Incidental water ingestion	3E-05	4E-06	2E-10
Total:	1E+01	2E-01	7E-07
UTILITY WORKER - TANK K			
Inhalation	6E+03	8E+01	1E-04
Contact with soil	2E-03	1E-04	1E-10
Contact with water	1E+00	1E-01	8E-07
Incidental soil ingestion	2E-04	2E-05	2E-11
Incidental water ingestion	3E-03	2E-04	1E-08
Total:	6E+03	8E+01	1E-04
FACILITY WORKER - DRAINAGE DITCH OUTFALLS			
Contact with soil	1E-03	7E-06	2E-09
Incidental soil ingestion	3E-04	2E-06	3E-10
Total:	2E-03	1E-05	2E-09
FACILITY WORKER - TANK K			
Inhalation	4E-04	3E-04	2E-08
FACILITY WORKER - TANK FARM			
Inhalation	8E 07	5E-07	2E-10
FACILITY WORKER - TANK F			
Inhalation	2E-08	2E-08	4E-11

Table taken from Arthur D. Little, Inc. Report entitled "Public Health and Ecological Risk Characterization for 50 Fordham Road Property, Wilmington/North Reading, Massachusetts" dated December 13, 1991.

Table 2-3

MARTIN MARIETTA CORPORATION

WILMINGTON/NORTH READING, MASSACHUSETTS
PHASE III FEASIBILITY STUDY

PRELIMINARY REMEDIAL ACTION GOALS, OBJECTIVES AND ACTIONS

Remedial Action Goals	Remedial Action Objectives	Potential Actions
Reduce groundwater concentrations to applicable standards	Achieve Method 1 groundwater standards at all groundwater monitoring locations	• Contaminant concentration reduction • Migration control • Source control
Reduce risk to utility workers posed by soil contamination in former tank K area, former tank farm and drum storage area, and eastern parking lot	Achieve Method 1 soil standards in former tank K area, former tank farm and drum storage area, and eastern parking lot; or	• Contaminant concentration reduction
	Permanently prevent exposure	• Activity and use limitations
To achieve a permanent solution, eliminate LNAPL as a source in former tank K area, former tank farm and drum storage area, and eastern parking lot	Eliminate LNAPL as a source for future contamination of environmental media	• LNAPL recovery or containment
Reduce risk to the environment posed by sediment concentrations in outfall basin 001	Reduce sediment concentrations to prevent toxicity to biological organisms	• Contaminant concentration reduction

2.3.1 Proposed Cleanup Levels for Groundwater

DEP has developed Method 1 standards for three different groundwater categories, GW-1, GW-2, and GW-3, based upon the characteristics of a given site and potential exposure. The GW-1 category includes areas of current and potential water supply use; the GW-2 category includes locations where there is a potential for vapor migration to indoor air; and the GW-3 category includes all locations as potential sources of discharge to surface waters. One or more of these categories can be applicable in any given location and the lowest standard for a given substance (from the applicable categories) is the Method 1 standard for that location. A number of criteria must be considered in determining the applicability of GW-1 standards. If any one of these criteria are met, then GW-1 standards apply. These criteria and a discussion of their relevance to this site follows:

Zone II - In the general vicinity of the site, Zone II delineations have only been approved for the Town of Wilmington (February 26, 1993). No groundwater in the contaminated area is within an approved Zone II, and therefore this criteria does not apply.

Interim Wellhead Protection Area (IWPA) - Based upon a review of DEP Water Supply maps, the 50 Fordham Road Property does not fall within the IWPA for public water supply wells in the towns of Reading, North Reading, Lynnfield, Peabody, Middleton or Danvers. The wetlands to the north of Concord Street are located, in part, within the IWPA for two public water supply wells within the Town of Reading, including Well 82-20 and the Town Forest Well (Figure 2-1). Therefore, based on this criteria, portions of the contaminated area fall within the GW-1 category.

DEP Water Supply maps indicate that there is no IWPA established around the former Stickney Well. Irrespective of these maps, the designation of an IWPA around the former Stickney Well would not be appropriate given that the well has been inactive since closure in 1978, and, as indicated by the Town of North Reading's Water Supply Source Optimization Analysis (Camp, Dresser & McKee, Inc., 1993) the Town has no plans to use the well. (Water supply plans to meet projected

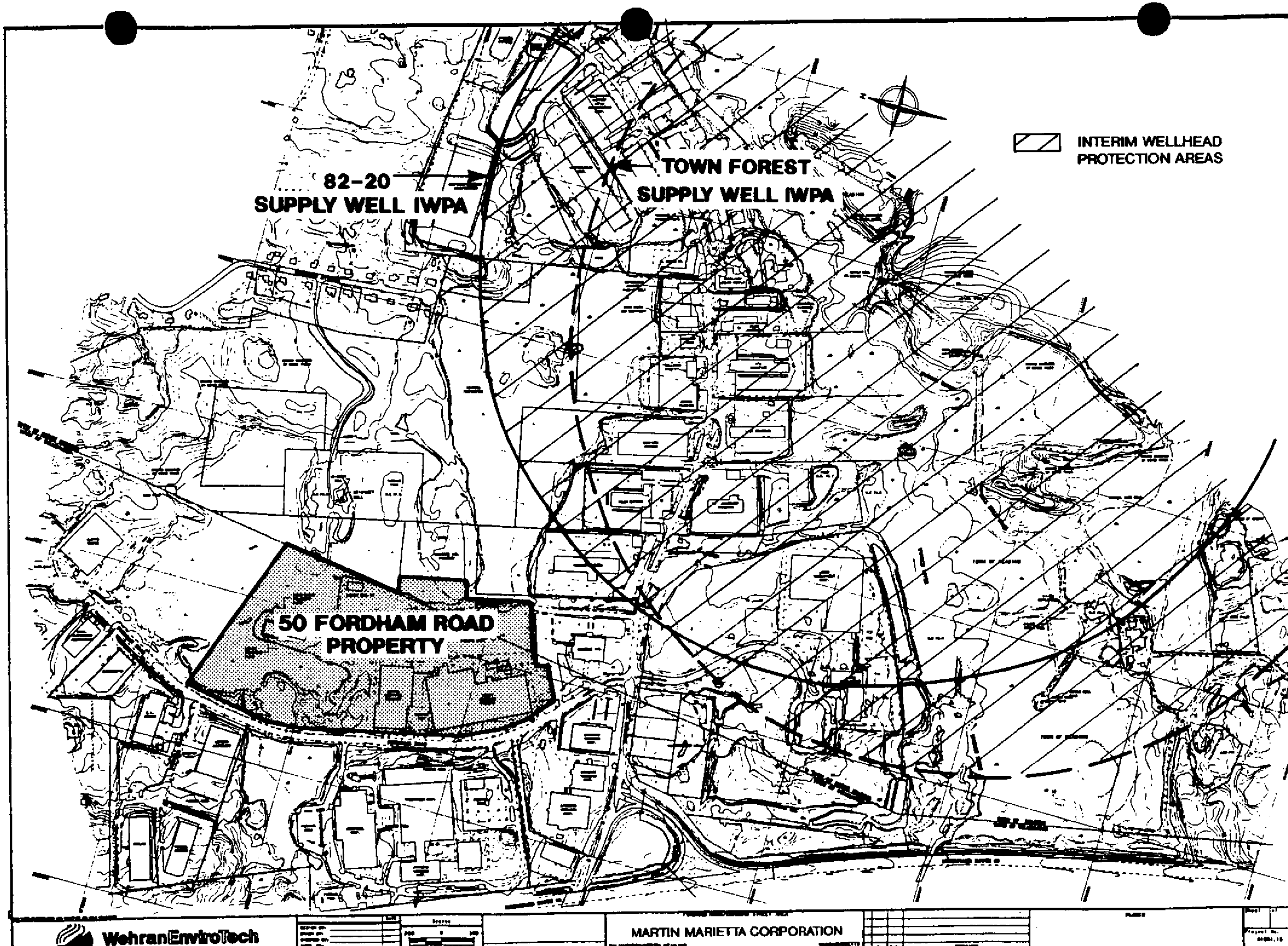


FIGURE 2-1 INTERIM WELLHEAD PROTECTION AREAS FOR READING WELLS

WEHRAN PROJECT NO. 01501.02

needs of the Town for both primary and backup sources of water through the year 2010 excluded the use of the former Stickney Well.) Furthermore, publicly documented problems with the well (high iron and manganese levels and declining yields due to siltation) which were unrelated to VOC contamination at the time of the well's closure, also preclude any reasonable likelihood that the well will ever be reused. Counsel for the Town of North Reading also indicated in a letter to DEP dated May 15, 1991 that

> "Because the Stickney Well was closed due to VOC contamination in December 1978, and remained closed during the relevant period set forth in the Water Management Act, G.L.M. c21G, the Town lost its registration rights to the Ipswich River basin. Accordingly, we have been informed by the DEP that no new source approval for pumping from the Stickney Well or the Ipswich River basin will be granted by the Commonwealth based upon the Commonwealth's assessment that the Ipswich River basin is a deficit basin in terms of water resource availability."

Town counsel concluded that,

> "the Town does not anticipate that it will be utilizing any groundwater surrounding the Stickney Well as a public water supply."

Therefore, it appears that GW-1 standards do not apply to the area surrounding the former Stickney Well based on the IWPA criteria.

Potentially Productive Aquifer - The overburden aquifer beneath the site is classified by the U.S. Geological Survey as a moderate to high yield aquifer. However, future development of this portion of the aquifer is not reasonably foreseeable because the Ipswich River Basin has been identified by the Department of Environmental Management and U.S. Geological Survey as a deficit basin in terms of water resource availability (highly stressed aquifer), which indicates that additional withdrawals would have a negative impact on water supply and aquatic life. As indicated above, the Town has been informed by DEP that no new source approval for pumping from the Stickney Well or the Ipswich River basin will be granted due to limited water resources availability. Therefore, GW-1 standards do not apply with respect to future development of the aquifer.

Zone A of a Class A Surface Water Body - None of the waters on or adjacent to the site are classified as Class A surface water bodies. The Ipswich River is classified as a Class B surface water body along the inland sections. (314 CMR 5.06)

Absence of Public Water Supply Distribution System (500 feet or more from a public water supply distribution pipeline) - The 50 Fordham Rd. property and all parcels in the wetlands are within 500 feet of a public water supply distribution system.

Existing private wells (within 500 feet) - No active private wells have been identified within 500 feet of the property.

The criteria for applicability of the GW-2 category are that the groundwater must be within thirty (30) feet of an occupied building or structure and the average annual depth to groundwater in that area must be fifteen (15) feet or less. The average annual depth to groundwater at the site ranges from 0 - 10 feet. There are occupied structures on the 50 Fordham Road property, and at the far eastern end of the wetlands.

Based on the above analysis, GW-3 standards are applicable in all locations. In addition, GW-2 standards are applicable in those portions of the site that are within 30 feet of an occupied structure, including portions of the property and the far eastern end of the wetlands. GW-1 standards are applicable to groundwater only within IWPAs for the Reading wells (Figure 2-1). Table 2-4 presents the applicable Method 1 groundwater standards for all substances detected at the site in any location at concentrations exceeding any of the Method 1 standards.

In addition to the applicable Method 1 standards, Table 2-4 also shows cleanup objectives for groundwater at the site. These cleanup objectives are the lowest of the applicable standards for any portion of the site, in most cases the GW-1 standards. The

Table 2-4

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
PHASE III FEASIBILITY STUDY
APPLICABLE GROUNDWATER STANDARDS AND CLEANUP OBJECTIVES

Compound	Applicable Cleanup Standard-IWPA (GW-1)[a]	Applicable Cleanup Standard-GW-2 Areas	Applicable Cleanup Standard-Other Locations (GW-3)	Cleanup Objective-All Locations
Volatile Organic Compounds (ug/l)				
Benzene	5	2,000	7,000	5
Bromomethane	10	2	50,000	2
1,1-Dichloroethane	70	9,000	50,000	70
1,1-Dichloroethene	7	1	50,000	1
cis-1,2-Dichloroethene	70	50,000[c]	50,000	70
trans-1,3-Dichloropropene[b]	0.5	5	2,000	0.5
Ethylbenzene	700	4,000[c]	4,000	700
Methylene Chloride	5	50,000	50,000	5
1,1,2,2-Tetrachloroethane	2	20	20,000	2
Tetrachloroethene	5	3,000	5,000	5
Toluene	1,000	6,000	50,000	1,000
Trichloroethene	5	300	20,000	5
Vinyl Chloride	2	2	600	2
Xylenes	10,000	6,000	50,000	6,000
Acid Base Neutral Compounds (ug/l)				
Bis(2-ethylhexyl)phthalate	6	30[c]	30	6
Inorganic Compounds (ug/l)				
Arsenic	50	400[c]	400	50
Total Petroleum Hydrocarbons (ug/l)	1,000	50,000[c]	50,000	1,000

a GW-2 would be also be applicable within the IWPA and within 30 feet of an occupied structure (the far end of the wetlands.

b Same as 1,3-Dichloropropene

c GW-3 standards are applicable in all cases; for these substances either there is no GW-2 standard or the GW-3 standard is lower than the GW-2 standard and the GW-3 standard is applicable achievement of these cleanup objectives is not required for the achievement of a level of No Significant Risk in locations where they are not the applicable standard. However, these objectives will be used in the identification, evaluation, and implementation of remedial alternatives in order to expedite achievement of and better maintain GW-1 standards in the IWPA.

2.3.2 Proposed Cleanup Levels for Soil

Method 1 standards have been developed by DEP for three different soil categories, based on the range of potential for exposure. Category S-1 has the highest potential for exposure (i.e. children in a residential setting) while category S-3 has the lowest potential for exposure. Category S-3 includes soil that is accessible but children are not present and adult frequency and intensity of use are low; potentially accessible with a low frequency and intensity of use by children; potentially accessible and children are not present and adult frequency or intensity of use is low; or the soil is isolated (greater than 15 feet under pavement) regardless of exposure potential.

The property is an industrial facility and is fenced with access limited. The risk assessment evaluated exposure to children in the drainage ditch area, but found that risks to this receptor group were not significant. As a result, adult facility (and utility) workers are the receptors that could potentially be exposed to soil contamination at the site (i.e. infrequently by excavation), and category S-3 standards are applicable. In addition to consideration of direct exposure, the applicable soil standards are based on the applicable groundwater category. As discussed above, the applicable groundwater category for the property is GW-2. Table 2-5 shows the applicable soil standards (S-3, GW-2). This table also shows the cleanup objectives based on soil category S-3 and groundwater category GW-1 when they are lower than the applicable soil standards. These objectives also serve the purpose of expediting the achievement of and better maintaining GW-1 standards in the IWPA.

The only soil exposure point concentrations at the site which exceeded the soil cleanup objectives are ethylbenzene, toluene and xylenes in the former tank K area, and total petroleum hydrocarbons in other portions of the site. However, the results of the risk assessment (Table 2-3) showed potential risks above regulatory standards to utility workers exposed during excavations in 1) the former tank K area, 2) the former tank farm/drum

Table 2-5

MARTIN MARIETTA CORPORATION

WILMINGTON/NORTH READING, MASSACHUSETTS

PHASE III FEASIBILITY STUDY

APPLICABLE SOIL CLEANUP STANDARDS AND OBJECTIVES

TABLE 3: MI: S2 Std.

Compound	Applicable Cleanup Standard (S-3/GW-2)	Cleanup Objective
Volatile Organic Compounds (ug/g)		
Benzene	100	10 S2/GW1
Ethylbenzene	500[a]	80 S2/GW1
Tetrachloroethene	300	0.5 S2/GW1
Toluene	500	90 S2/GW1
Trichloroethene	20	0.4 S2/GW1
Vinyl Chloride	0.3	0.3[b] S2/GW2
Xylenes	500	500[b] S2/GW2
Total Petroleum Hydrocarbons (ug/g)	5,000	5,000 → 2500 S-2 cat.

a S-3/GW-3 standards are applicable at all S-3 locations; for these substances the S-3/GW-3 standard is lower than the S-3/GW-2 standard and is shown as the applicable standard

b For substances where the S-3/GW-2 standard is lower than the S-3/GW-1 standard, the applicable standard is presented as the cleanup objective

TABLE 4: Method 1 soil cat. S-3 std.

benzene 10 PPM.
ethylbenzene 80 ppm.
PCE 0.5 PPM.
Toluene 90 ppm
TCE 0.4 PPM
VC 0.4 PPM
X 800

TPH = 5000 ug/g

ONLY DIFFERENCE IN S2/GW-1 and S3/GW1 FOR ABOVE MENTIONED CONTAMINANTS IS TPH.

storage area, and 3) the employee parking lot. The estimated risks to the utility workers are based upon modeling of air concentrations in an excavation based on measured soil gas concentrations. In order to address these estimated risks, soil gas contaminants which contributed to the excess risk were also included in Table 2-5 (benzene, tetrachloroethylene, trichloroethane, and vinyl chloride).

2.3.3 Proposed Cleanup Levels for Sediment

No human health risks were identified associated with sediment contamination at the site. However, the results of the ecological risk characterization (ADL 1991) showed a potential for adverse ecological impacts based upon metal concentrations in the drainage ditch, and metal, phthalate and TPH concentrations in the outfall basins. ADL (1991) concluded that the contamination in both of these locations was localized in nature and did not pose a risk to the wetlands at large.

Wehran (1992) conducted a literature search to assess background metal concentrations in wetland sediment settings similar to that east of Outfall 001. The literature search concluded that elevated metal concentrations in sediments near Outfall 001 were restricted to a localized area consisting of upland fill near locations WL-1 through WL-5. Elevated metal concentrations were not observed in sediment further east of the edge of the parking lot. Based on the conclusion that metal concentrations in the wetlands sediment were not elevated above background, and since the upland areas of elevated metals concentrations were localized and not thought by ADL to pose a risk to the wetland, no cleanup levels are identified for metals in sediment.

In order to evaluate risks associated with phthalate sediment concentrations, considering the sensitivity of certain aquatic organisms to low levels of phthalates in water, ADL considered the potential for phthalates in sediments to partition into the surface water. While previous sampling had not detected phthalates in the surface water, ADL's estimated water concentrations (through partitioning) exceeded the Ambient Water Quality Criteria. Therefore, the risk assessment concluded that a potential risk was associated with the phthalate concentrations in the outfall basins. Since the Method 1 (S-3, GW-1) soil standard for bis(2-ethylhexyl)phthalate is 100 ppm (well above any detected phthalate sediment concentration), there are no ecotoxicological criteria, and phthalates were not detected in surface waters, a sediment cleanup level for phthalates has not been identified.

Similarly, there are no ecotoxicological indices to evaluate TPH sediment concentrations. However, the Method 1 (S-3) soil standard for petroleum hydrocarbons of 5,000 ppm was selected as the cleanup objective for sediment. As a soil standard, it is protective of human health, welfare and the environment. As such, it was selected as a sediment cleanup objective to address any potential risks to environmental receptors.

3.0 IDENTIFICATION AND SCREENING OF TECHNOLOGIES

3.1 IDENTIFICATION AND INITIAL SCREENING OF TECHNOLOGIES/PROCESS OPTIONS

The objective of this step is to identify general response actions and engineering technologies and process options that are potentially applicable to remediation at the site. Potential remedial technologies to address each of the media of concern are identified, based on previous experience with similar contaminants at other sites and published literature. Potential remedial technologies and process options are screened according to their technical applicability to the media and contaminants of concern, and the specific conditions present at the site. Only those technologies that are clearly inappropriate for the site are eliminated during this initial screening process. Tables 3-1 and 3-2 present those technologies and process options which may be applicable at the site for soil/sediment and groundwater, respectively.

A review of this initial screening for soil and sediment results in the following conclusions:

1. No Action is retained as a baseline.
2. The only retained institutional action is deed restriction. The only direct exposure to surficial soil is at Outfall 001. The sediments must be treated to meet the cleanup level of 5000 mg/kg TPH. Therefore, fencing would not address this area.
3. Containment by capping has been eliminated because it is not an effective technology for soils at this site. The majority of the site is already paved which precludes surficial contact with contaminated soils and minimizes infiltration.
4. Containment by subsurface vertical barriers has limited applicability. Based upon the remedial response objectives of soil contaminant concentration reduction and LNAPL (separate phase product) recovery, vertical barriers for containment of separate phase product and contaminated soils are not applicable. However, sheet pile walls will be evaluated for wall stabilization in localized soil excavation. The other vertical barrier technologies are not amendable to this type of temporary usage.

Table 3-1
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
No Action	None	Not Applicable	No additional action	Retained for baseline comparison of alternatives
Institutional Actions	Access Restrictions	Fencing	Provide security fence to restrict direct exposure to surficial contamination	Eliminated - direct exposure to surficial contamination limited to outfall 001, fencing will not address the remedial response goal of reducing sediment concentrations
		Deed Restriction	Deed restriction on future land use	Potentially applicable
Containment	Cap	Clay & Soil	Compacted clay covered with soil over areas of contamination	Eliminated - site is paved, infiltration is minimal
		Asphalt	Application of a layer of asphalt over areas of contamination	Eliminated - site is paved, infiltration is minimal
		Concrete	Installation of a concrete slab over areas of contamination	Eliminated - site is paved, infiltration is minimal
		Multi-Media	Clay and synthetic membrane covered	Eliminated - site is paved, infiltration is minimal
	Subsurface Vertical Barriers	Geomembrane Curtain	Installation of a geomembrane sheet in a trench down to a confining soil layer	Eliminated - no implementation advantage relative to sheet pile walls
		Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to form a sealed wall in the soil matrix	Eliminated - no implementation advantage relative to sheet pile walls
		Slurry Wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry	Eliminated - no implementation advantage relative to sheet pile walls

Table 3-1

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Containment	Subsurface Vertical Barriers	Sheet Pile Wall	Installation of interconnecting steel pilings around an area of contamination	Potentially applicable - commonly used method of soil stabilization
		Vibrating Beam	Vibrating force to advance beams into the ground with injection of slurry as beam is withdrawn to form a low permeability wall	Eliminated - no implementation advantage relative to sheet pile walls
	Horizontal Barrier	Grout Injection	Pressure injection of grout at depth through closely spaced drilled holes	Eliminated - difficult to implement in the saturated zone
Removal	Excavation	Soil Excavation	Removal of unconsolidated overburden including the unsaturated zone	Potentially applicable for unsaturated soils and for trench work required for other technologies
	Dredging	Mechanical Dredging	Removal of contaminated sediments from shallow streams, rivers, lakes and other basins of water	Potentially applicable for areas of isolated contamination (Outfall 001 and 002)
Treatment (In-Situ)	Biological	Aerobic	In-situ stimulation and enhancement of aerobic degradation process	Eliminated - difficult to implement over a large contaminated area
		Anaerobic	In-situ stimulation and enhancement of anaerobic degradation process	Eliminated - not a proven technology, logistics of rendering a site anaerobic have not been developed
	Physical/Chemical	Soil Flushing	System of wells flush soils with an aqueous based wash solution to remove highly water soluble contaminants	Eliminated - difficult to implement on a paved site; potential for migration to uncontaminated areas

Table 3-1
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Treatment (In-Situ)	Physical/Chemical	Soil Vapor Extraction	A vacuum pump is attached to a system of wells to draw air from the contaminated zone to the surface for treatment or discharge. VOCs are transferred from soil moisture to the air	Potentially applicable
		Vitrification	High temperature applied to contaminated soil to melt material and form an inert glass product	Eliminated - extremely expensive, has been restricted to radioactive and very highly toxic wastes
Treatment (Ex-Situ)	Thermal	On-Site Incineration	Destruction of organics by oxidation using an on-site incinerator	Eliminated - not practical due to large waste volume and permitting concerns
		Off-Site Incineration	Destruction of organics by oxidation using an off-site incinerator	Potentially applicable
		Low Temperature Thermal Desorption (on or off-site)	Removal of VOCs by heating the soil to volatilize the organic contaminants	Potentially applicable
	Physical/Chemical	Soil Washing	Excavated soils are contacted with surfactants to remove contaminants	Potentially applicable for contaminated soils from excavations
		Thickening/Dewatering	Removal of water from excavated soils or sediments to achieve an acceptable form for subsequent disposal	Potentially applicable for dredged sediment near outfalls and excavated soils

Table 3-1
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Treatment (Ex-Situ)	Physical/Chemical	Asphalt Batching (on or off-site)	Alter the physical and/or chemical state of the contaminants within the soil rendering them less leachable, less toxic and more easily handled, transported and disposed	Potentially applicable
	Biological	Aerobic	Contamination in excavated soils is degraded by indigenous or preselected micro-organisms in an ex-situ storage area.	Potentially applicable
Disposal	Off-Site	Treatment/Storage/ Disposal (TSD) Facility	Transfer of untreated/treated soils and/or treatment residue to an approved TSD	Potentially applicable
	On-Site	Reuse	On-site utilization of treated soils	Potentially applicable for treated soils

Table 3-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
No Action	None	Not Applicable	No additional action beyond on-going monitoring of wells	Required for baseline comparison of alternatives
Institutional Actions	Access Restrictions	Deed Restrictions	Deeds for properties in the affected areas would include restriction on wells	Eliminated based on the provision of 30 CMR 40.1012(3)
Containment	Cap	Clay & Soil	Compacted clay covered with soil over areas of contamination	Eliminated - will not impede migration of contaminated groundwater
		Asphalt	Spray application of a layer of asphalt over areas of contamination	Eliminated - will not impede migration of contaminated groundwater
		Concrete	Installation of a concrete slab over areas of contamination	Eliminated - will not impede migration of contaminated groundwater
		Multi-Media	Clay and synthetic membrane covered by soil over areas of contamination	Eliminated - will not impede migration of contaminated groundwater
	Vertical Barriers	Geomembrane Curtain	Installation of a geomembrane sheet in a trench down to confining soil layer	Eliminated - no implementation advantage relative to sheet pile wall
		Grout Curtain	Pressure injection of grout in a regular pattern of drilled holes to form a sealed wall in the soil matrix	Eliminated - difficult to implement compared to other impermeable barriers, site conditions preclude keying-into the bedrock
		Slurry Wall	Trench around areas of contamination is filled with a soil (or cement) bentonite slurry	Eliminated - no implementation advantage relative to sheet pile wall

Table 3-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Containment	Vertical Barriers	Sheet Pile Wall	Installation of interconnecting steel pilings around an area of contamination	Potentially applicable, implemented with construction of interceptor trench
		Vibrating Beam	Vibrating force to advance beams into the ground with injector of slurry as beam is withdrawn to form a low permeability wall	Eliminated - difficult to implement compared to other impermeable barriers, site conditions preclude keying-into bedrock
	Horizontal Barrier	Grout Injection	Pressure injection of grout at depth through closely spaced drilled holes to form a horizontal bottom seal	Eliminated - difficult to implement in the saturated zone
Collection	Extraction	Extraction Wells	Series of wells to extract contaminated groundwater	Potentially applicable
	Subsurface Drains	Interceptor Trenches	Perforated pipe in trenches backfilled with porous media to collect contaminated groundwater and separate phase product	Potentially applicable, particularly in the area of Eastern Parking Lot
Treatment	Biological	Aerobic	Degradation of organics using micro-organisms in an aerobic environment	Eliminated - not applicable for low concentrations of groundwater contaminants
		Anaerobic	Degradation of organics using micro-organisms in an aerobic environment	Eliminated - not applicable for low concentrations of groundwater contaminants
	Biophysical	Granular Activated Carbon (GAC) Fluidized Bed	Degradation of organics by aerobic micro-organisms and adsorption of non-biodegradable organics onto granular activated carbon	Eliminated - not applicable for low concentrations of groundwater contaminants

Table 3-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Treatment	Biophysical	Powdered Activated Carbon Treatment (PACT[R])	Degradation of organics by aerobic micro-organisms and adsorption of non-biodegradable organics onto powdered activated carbon	Eliminated - not applicable for low concentrations of groundwater contaminants
		Biofiltration	Vapors or off-gases are filtered through a bed, which contains a biologically active filter material from compost, peat and polystyrene	Eliminated - not readily implemented due to limited number of available vendors and the need for a large area for equipment set-up
	Physical/Chemical	Air Stripping	Mix large volumes of air with water in a packed column or shallow tray aerator to promote transfer of VOCs to air	Potentially applicable
		Carbon Adsorption	Adsorption of contaminants onto activated carbon by passing water or vapor through carbon column	Potentially applicable for both groundwater and off-gas treatment
		Chemical Oxidation	Destruction of organics by oxidation using ozone or hydrogen peroxide catalyzed by ultraviolet light	Potentially applicable
		Chemical Precipitation	Addition of chemicals to alter the equilibria to reduce solubility of the contaminants	Potentially applicable as pretreatment to air stripping, carbon adsorption or chemical oxidation
		Filtration	Removal of suspended and colloidal impurities from water by passage through a bed of granular material or filter bags	Potentially applicable as pretreatment to air stripping, carbon adsorption or chemical oxidation
		Gravity Separation/ Sedimentation	Separation of solid-liquid and/or liquid-liquid wastes utilizing gravitational settling	Potentially applicable for removal of separate phase product or in conjunction with chemical precipitation

centrifuge?

Table 3-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Treatment	Physical/Chemical	Ion Exchange	Contaminated water is passed through a resin bed where ions are exchanged between resin and water	Eliminated - not applicable for the removal of organics or total dissolved solids
		Reverse Osmosis	Utilize pressure and semi-permeable membranes to separate non-ionic materials from an aqueous stream	Potentially applicable for the removal of total dissolved solids
		Neutralization	Alteration of the chemical nature of waste acids and alkalies to reduce chemical activity and corrosiveness	Potentially applicable in conjunction with chemical precipitation
		Steam Stripping	Removal of VOCs by steam	Eliminated - no technological advantage relative to air stripping
	Thermal	Catalytic Oxidation	Incineration process which utilizes catalysts to increase the oxidation rate of wastes and chemically decompose the waste	Potentially applicable for off-gas treatment of air stripping and soil vapor extraction
	In-Situ	Bioreclamation	Degradation of organics using micro-organisms	Eliminated - difficult to implement due to large area of groundwater requiring treatment
		Air Sparging	System of wells to inject air into groundwater to remove contaminants by volatilization	Potentially applicable in areas employing soil vapor extraction
		Chemical Oxidation	System of injection wells to introduce an oxidizer, such as hydrogen peroxide, to degrade contaminants	Eliminated - difficult to implement large scale in-situ system

Table 3-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

INITIAL SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS

GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Options	Technology Description	Screening Result
Treatment	In-Situ	Permeable Treatment Bed	Downgradient trenches backfilled with activated carbon to remove contaminants from water	Eliminated - difficult to implement due to large area and depth of groundwater contamination
Disposal	On-Site Discharge	Injection Wells	Pump treated groundwater into injection wells to enhance groundwater collection	Potentially applicable
		Surface Water	Discharge treated groundwater to wetlands	Potentially applicable
		Wastewater Treatment Plant	Discharge untreated groundwater to on-site Ametek wastewater treatment plant	Eliminated - plant not designed to handle the hydraulic loading nor the contaminants
	Off-Site Discharge	Publically Owned Treatment Works (POTW)	Discharge untreated groundwater to POTW	Eliminated - not practical to transport large volumes of recovered groundwater over periods of years to a POTW
		Treatment/Storage/ Disposal Facility (TSD)	Transport and treat contaminated groundwater at an approved TSD facility	Eliminated - not practical to transport large volumes of recovered groundwater over periods of years to a TSD

5. Removal of soils/sediments by excavation and dredging has been retained. All areas may not be effectively treated in-situ and excavation would be required for ex-situ treatment methods.
6. In-situ soil treatment methods, with the exception of soil vapor extraction, were eliminated. The primary concerns with these methods were the containment of contaminants (e.g., flushing of contaminants could result in migration to uncontaminated areas), efficiency of treatment during implementation of these technologies over large contaminated areas (e.g., for biological treatment difficult to assure that a viable bacterial population has been cultivated over the entire treatment area and to ascertain when treatment is complete) and cost (vitrification).
7. Ex-situ soil treatment methods show greater potential than their in-situ counterparts. The only ex-situ method which was eliminated was on-site incineration because it would be difficult or impossible to permit.

A review of the initial screening for groundwater results in the following conclusions:

1. No Action has been retained as a baseline.
2. No institutional action have been retained. Groundwater use restrictions were eliminated. 30 CMR 40.1012(3) states "activity and use limitations shall not be used in support of a Response Action Outcome to prevent a significant risk of harm to health, safety, public welfare, or the environment from oil and/or hazardous material in groundwater."
3. Containment by capping is not an effective technology for groundwater remediation and has been eliminated. The majority of the site is already paved which reduces infiltration.
4. Containment by subsurface barriers has limited applicability. The areal and vertical extent of contaminated groundwater precludes encircling the entire plume. Due to the nature of the bedrock, vertical barriers could not be keyed-into a competent confining layer. Subsurface barriers will be considered for reduction of flow to interceptor trenches in the overburden.

5. Collection of groundwater by both extraction wells and interceptor trenches are both applicable at the site.

6. All biological and biophysical treatment technologies for groundwater were eliminated based upon the relatively low concentration of biodegradable material in the groundwater. It would be very difficult to maintain sufficient biological growth to ensure adequate treatment.

7. The only physical/chemical treatment technologies which were eliminated were ion exchange and steam stripping. Ion exchange is a technology which is applicable to the removal of particular ions (e.g., copper, lead). Ion exchange is not effective for total dissolved solids (TDS) removal, in that, one ion is exchanged for another. It's potential use for TDS reduction would be the only reason to retain ion exchange. Steam stripping is effective for the removal of high concentrations of organics (1-20%). However, concentrations of less than 1% (10,000 mg/L) are more effectively treated by other technologies. Steam stripping, for the contaminants of concern, shows no technical advantage to air stripping. A broad range of physical/chemical technologies was retained because a broad range of pollutants are being treated [metals (iron and manganese), solvents, dissolved solids, solubilized and separate phase product].

8. As with soil treatment, in-situ groundwater treatment technologies (with the exception of air sparging) were eliminated due to the difficulties of implementing them over a large area of contamination. Air sparging was retained as potentially applicable for use with soil vapor extraction (the only in-situ soil treatment technology retained).

9. On-site disposal of treated or untreated groundwater to the on-site wastewater treatment plant was eliminated because the facility is not designed to handle either the hydraulic loading or the contaminants present. Surface water discharge and reinjection wells have been retained.

10. Off-site disposal of treated or untreated groundwater was eliminated because transportation of large quantities of water to a treatment/disposal site over extended periods of time makes this option cost-prohibitive.

3.2 DETAILED SCREENING OF REMEDIATION TECHNOLOGIES

In this step Wehran has evaluated the technologies and process options that passed the initial screening on the basis of three criteria: effectiveness, implementability and cost (with primary emphasis on effectiveness). For the purposes of this detailed screening, Wehran evaluated these criteria using the following factors. Only those factors which have significant impact on the screening of these alternatives are included in the descriptions of each technology.

Effectiveness - Each technology process option is screened on effectiveness relative to other process options within the same technology type. The following factors were used to screen effectiveness:

(1) The potential effectiveness of process options for accommodating estimated areas or volumes of media, and for meeting the remedial action objectives;

(2) The potential impacts to human health and the environment during the construction and implementation phase of remediation; and

(3) The potential performance and reliability of the technology for remediating the media of concern, under existing site conditions.

To aid in evaluating technology effectiveness, the physical and chemical properties of the contaminants of concern are summarized in Table 3-3.

Implementability - This criterion encompasses both the technical and administrative feasibility of implementing the technology process option. Emphasis is placed on the institutional and constructability aspects of implementability, such as the following:

(1) The ability to obtain necessary permits for any off-site or on-site actions;

(2) The availability (including capacity) of treatment, storage, and disposal services;

(3) The availability of necessary equipment and skilled workers to implement the technology;

(4) The practicality of implementing the technology given existing conditions;

(5) The social and political ramifications of implementing the technology.

Table 3-3
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PHYSICAL AND CHEMICAL PROPERTIES OF CONTAMINANTS

Compound	Molecular Weight	Solubility mg/l	Specific Gravity	Octanol/Water Partition Coefficient K_{ow}	Sorption Partition Coefficient K_{oc}	Vapor Pressure mm Hg @10°C	Boiling Point °C	Henry's Law Constant atm · m^3/mol @ 10°C	Adsorption Capacity (mg/g) @ 1000 ppb
Volatile Organic Compounds	Ref. (1)	Ref. (2)	Ref. (1)	Ref. (2)	Ref. (2)	Ref. (1)(4)	Ref. (1)	Ref. (5)	Ref. (7)
Benzene	78.12	1630 @ 10°C	0.8765	130	95	45.6	80.1	3.30×10^{-3}	49 (8)
Bromomethane	94.94	13,200 @ 25°C	1.6755	15	85	964.1	3.6	9.12×10^{-3} (6)	-
1,1-Dichloroethane	98.96	6330 @ 10°C	1.1757	60	30	111.2	57.3	3.67×10^{-3}	1.8
1,1-Dichloroethene	96.94	2400 @ 15°C	1.2180	65	65	291.5	37.0	1.54×10^{-2}	4.9
c-1,2-Dichloroethene	96.94	3500 @ 25°C (3)	1.2837	75 (3)	40 (3)	98.8	60.3	2.70×10^{-3}	12
t-1,3-Dichloropropene	110.97	2800 @ 15°C	1.2240	25	35	9.4	112.0	4.90×10^{-4} (6)	-
Ethylbenzene	106.17	140 @ 15°C	0.8670	1290	155	4.0	136.2	3.25×10^{-3}	175
Methylene Chloride	84.93	21,200 @ 10°C	1.3266	20	10	222.3	40.0	1.40×10^{-3}	1.3
1,1,2,2 Tetrachloroethane	167.85	2900 @ 20°C	1.5953	300	75	2.2	146.2	3.29×10^{-4}	11

Table 3-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PHYSICAL AND CHEMICAL PROPERTIES OF CONTAMINANTS

Compound	Molecular Weight	Solubility mg/l	Specific Gravity	Octanol/Water Partition Coefficient K_{ow}	Sorption Partition Coefficient K_{oc}	Vapor Pressure mm Hg @10°C	Boiling Point °C	Henry's Law Constant atm · m^3/mol @ 10°C	Adsorption Capacity (mg/g) @ 1000 ppb
Tetrachloroethene	165.83	150 @ 25°C	1.6227	335	270	7.7	121.0	8.45×10^{-3}	51
Toluene	92.15	368 @ 10°C	0.8669	370	130	12.4	110.6	3.80×10^{-3}	100
Trichloroethene	131.29	1100 @ 25°C	1.4642	530	95	32.7	87.0	5.37×10^{-3}	28
Vinyl Chloride	62.50	950 @ 15°C	0.9106	4.0	2.5	1750.8	-13.4	1.50×10^{-1}	0.002 (9)
o-Xylene	106.17	178 @ 25°C	0.8802	1045	130	2.7	144.4	2.85×10^{-3}	174
m-Xylene	106.17	161 @ 25°C	0.8642	1585	1585	3.3	139.1	4.10×10^{-3}	230
p-Xylene	106.17	162 @ 25°C	0.8611	1460	205	3.6	138.3	4.19×10^{-3}	200
Acid/Base Neutral									
Bis(2-ethylhexyl)Phthalate	390.56	2.85×10^{-1} @ 25°C (13)	0.990	4.5×10^{4}	1.0×10^{5}	2.0×10^{-7} (2)	385.0	3.6×10^{-7} (6)	11,300

Table 3-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PHYSICAL AND CHEMICAL PROPERTIES OF CONTAMINANTS

Compound	Molecular Weight	Solubility mg/l	Specific Gravity	Octanol/Water Partition Coefficient K_{ow}	Sorption Partition Coefficient K_{oc}	Vapor Pressure mm Hg @10°C	Boiling Point °C	Henry's Law Constant atm · m^3/mol @ 10°C	Adsorption Capacity (mg/g) @ 1000 ppb
Petroleum Hydrocarbons	Ref. (1)	Ref. (8)	Ref. (1)	Ref. (12)	Ref. (12)	Ref. (1)(4)	Ref. (1)	Ref. (6)	
Gasoline	102.2 (10)	219 (10)	0.7457 (10)	-	-	188.6 (10)	30 - 215	7.4×10^{-1} (10)	-
Stoddard solvent	127.0	2.6 (11)	0.77	-	-	1.9	150 - 200	1.2×10^{-1}	-
n-Nonane	128.26	0.07 @ 20°C	0.7176	-	17,600 (10)	2.0	150.8	4.8	-
1,2,3 Trimethylbenzene	120.2	75.2 @ 25°C	0.8944	3550	610	0.7	176.1	-	-
1,2,4 Trimethylbenzene	120.2	57.0 @ 20°C	0.8758	4465	-	0.9	169.3	2.5×10^{-3}	-
1,3,5 Trimethylbenzene	120.2	72.6 @ 20°C	0.8652	2630	630	1.1	164.7	2.4×10^{-3}	-

1. CRC Handbook of Chemistry & Physics, 61st Edition, CRC Press, 1980.
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5. USEPA, Soil Vapor Extraction Technology: Reference Handbook, Februray 1991, EPA/540/2-91/003.
6. Calculation: H = Vapor Pressure (atm)/solubility (mol/m^3).
7. AWWA, Water Quality and Treatment, McGraw-Hill, 1990.
8. Verschueren, K., Handbook of Environmental Data of Organic Chemicals, Van Nostrand Reinhold, 1977.
9. Westates Carbon, Liquid Phase Adsorption Isotherm for Vinyl Chloride
10. USEPA, Assessing UST Corrective Action Technology: A Scientific Evaluation of Mobility and Degradability of Organic Contaminants in Subsurface Environments, September 1991, EPA/600-2-91/053.
11. Kroopnick, P. & S. Fischbein, "Remediation Techniques for Groundwater and Soils Contaminated with Mineral Spirits", Petroleum Hydrocarbons and Organic Chemicals in Groundwater, NWWA, API, 1989.
12. MacKay, D., Handbook of Physical Chemical Properties adn Environmental Fate for Organic Chemicals, Vol. I, Lewis Publishers. 1992.
13. MacKay, D., Handbook of Physical/Chemical Properties and Environmental Fate for Organic Chemicals, Vol. 2, Lewis Publishers. 1992.

In addition to the above criteria, specific constraints of the site will be considered, such as the presence of the wetlands and utilities.

Cost - At this stage of the evaluation, costs are developed on a qualitative basis as "low", "moderate", or "high". Relative capital, and operation and maintenance (O&M) costs (based on engineering judgement), are used to compare technology process options within the same technology type. The cost criterion plays only a limited role in eliminating options during this detailed screening of technologies.

The following subsections present the evaluations of the technology process options. The evaluations are organized by the various media of concern.

3.2.1 Soils

3.2.1.1 No Action

Description - The No Action general response action implies that no further remedial actions will be conducted. Under this alternative, the gasoline that has accumulated in the Tank K area and the Stoddard solvent that has not been recovered to date from the Tank Farm and Eastern Parking Lot areas would be left in place. Also, no remedial action would be conducted to address the TPH and BTEX contamination in the unsaturated soils in these areas. Since the site is paved, infiltration is not significant and contaminants would not be flushed from the soils. Finally, no remedial action would be conducted to address the TPH in the wetland sediments.

Effectiveness - Under this general response action, protection of human health would be maintained as there is no significant impact under current conditions. However, there could remain some long-term potential for exposure to the remaining contamination, for example, during excavation for utility construction or repairs. Since the contamination is above, on and below the water table, the No Action general response action would not mitigate the leaching of petroleum-related constituents to the groundwater. Therefore, groundwater cleanup levels would not be achieved.

Implementation - The No Action general response action can be easily implemented. Potential constraints such as the availability of TSD facilities, the need for permits, the availability of equipment and labor are not a concern. Since no remedial actions are undertaken, there is no implementation impact on human health and the environment.

Cost - There are no capital and O&M costs associated with the No Action general response action.

Screening - No Action would not meet the remedial action objectives of attaining cleanup levels. However, No Action will be retained and considered a remedial action alternative to serve as a baseline for comparison with other alternatives in Section 5.0.

3.2.1.2 Institutional Actions

Description - Institutional actions are controls which can be used to minimize the potential for exposure to the contaminated media at the site. For contaminated soils, the only control retained is deed restrictions to limit future land use.

Effectiveness - Institutional actions would help to ensure no future human exposure to the contamination which would remain in the soils at the site. Such actions would not minimize the migration of contaminants from subsurface soils to the groundwater. However, much of the site is already fenced and paved (which limits the majority of potential exposure to surface soil/sediments). Institutional actions would be largely protective of human health, but would not achieve the remedial action objective of meeting cleanup levels, as subsurface soils and sediments would continue to leach petroleum-related constituents to the groundwater and surface water, respectively.

Implementability - Deed restrictions for future land use on-property may be easily instituted, but, depending on the type of controls instituted, cooperation among various governmental agencies and property owners may be required. No off-site TSD facilities or permits are required.

Cost - The capital cost to implement this option is low. There are no long-term O&M costs associated with soil-related institutional actions.

Screening - Institutional actions by themselves will not achieve the remedial action objectives. However, they may be combined with other remedial technologies to achieve the remedial action objectives. As a result, they are retained for further evaluation as one component of a remedial action alternative.

3.2.1.3 Containment

In evaluating the general response action of containment for contaminated soils and groundwater, capping was eliminated. The subsurface soils containing separate phase product and residual petroleum contamination are in direct contact with the groundwater. Because the majority of the site is paved, capping the site would not significantly impact the migration of petroleum-related constituents to the groundwater. Therefore, only subsurface vertical barriers were evaluated further.

Subsurface vertical barriers are commonly used for in-situ containment of contaminated soils. The purpose of installing such barriers is to intercept, block, or otherwise control groundwater inflow and outflow to minimize contaminant migration to off-site areas and to enhance remediation. For complete containment, physical barriers must key into a low permeability underlying confining layer, which forms the bottom of the containment boundary. Given that there are no confining layers in overburden soils at the site, and that bedrock is fractured, there is no suitable low permeability layer to form the bottom of the containment boundary. In addition, due to the extensive area of contaminated soils, this technology would not be practical for addressing site-wide soil contamination. Subsurface barriers could be used to intercept separate phase product, or to form temporary containment during dredging of sediments at the outfalls. In the case of separate phase product, these barriers could be effective because they would not have to extend to the confining layer. Containment of the separate phase product in the Tank K Area (gasoline) and Eastern Parking Lot (Stoddard solvent) could be accomplished by the construction of a subsurface barrier east of wells WE-4S/4D and DP-6, respectively. The barriers would not be constructed to encompass all of the separate phase product, but rather to contain the leading edge of separate-phase product plumes. The barrier for the Tank K Area would be approximately 150 feet long; the Eastern Parking Lot barrier would be approximately 250 feet long. However, containment by itself will not address the remedial action objective to reduce soil TPH concentrations to less than 5000 mg/kg. Vertical barriers will only be considered for excavation stabilization. Product recovery will be accomplished through excavation or interceptor trenches. The only technology retained from the initial screening is sheet pile walls, which are evaluated below:

Sheet Pile Walls

Description - Sheet pile wall barriers are a proven technology to effect groundwater containment and diversion. A sheet pile wall barrier would be formed by driving interlocking steel or plastic sheet piles from the ground surface to a depth below the groundwater level.

No excavation would be required during installation given that the sheet piles are mechanically driven into the subsurface using a drop or vibratory hammer. Heavy equipment is desirable for fast driving and for preventing damage to the piles. Plastic sheet piles may include a joint sealer.

Effectiveness - When first placed in the ground, steel sheet pilings are quite permeable along interlocking seams. However, with time, fine soil particles are washed into the seams and groundwater flow is restricted. The time required for sealing depends on the rate of groundwater flow and the texture of the soil involved. The joint sealer included with plastic sheet piles is immediately effective in preventing the leakage of groundwater through the sheet pile barrier.

An advantage of steel sheet piles is that because they can be readily dismantled and installed at a new location, they can be used for temporary containment. Thus, sheet piling would be effective for containing and stabilizing areas to be excavated (e.g. in the vicinity of the outfalls).

Implementability - The availability of the required equipment is somewhat limited. The required labor, however, is readily available. No off-site TSD facilities or on-site treatment systems are required.

Cost - Moderate capital would be associated with implementation.

Screening - Sheet pile walls by themselves will not achieve the remedial action objectives. They may also be used with other remedial technologies, such as excavation, to achieve the remedial action objectives.

3.2.1.4 Removal

Excavation/Dredging

Description - Excavation/dredging is the process by which the contaminated soils/sediments are removed from the ground. Excavation/dredging is a major element for all of the ex-situ remedial actions evaluated in this feasibility study. Excavation/dredging is generally accomplished with conventional heavy construction equipment, such as backhoes, bulldozers, loaders, cranes and clam shells. Technical issues associated with excavation include:

- Treatment and disposal of soils contaminated with petroleum and chlorinated organics,
- Underground utilities in the area of excavation,
- Groundwater control for excavation and slope stability,
- Dewatering of excavated soils, and
- Treatment and disposal of recovered groundwater.

<u>Effectiveness</u> - Removal of the subsurface soils containing petroleum-related contamination (including separate phase product), in combination with treatment and/or disposal options, would permanently remove the source of the highest levels of groundwater contamination. However, the excavated area would have to be filled with clean fill material. That portion of the fill material placed below the water table would become contaminated through contact with contaminated groundwater and surrounding soils containing residual contamination. Excavation of petroleum or chlorinated solvent contaminated soils should be performed with strict health and safety protocols. Air monitoring should be conducted to determine whether vapor concentrations in the area are high enough to cause an explosion or health hazard.

<u>Implementability</u> - The equipment and labor required for excavation are readily available. The depth to groundwater is approximately 5-6 feet. Conventional backhoes can work to a maximum depth of 25 feet. The excavated soils would have to be treated and/or disposed. Clearances would be required for wetland disturbances and treatment and/or transport of contaminated soils. The time for implementation could be increased due to the significant rock material present in some areas. The area involved with the Eastern Parking Lot is approximately 35,000 square feet and that with the Tank K area is approximately 20,000 square feet. Excavation of the Eastern Parking Lot and Tank Farm areas would represent significant disturbances to the existing operations at the Ametek facility. The portion of the Eastern Parking Lot which may require excavation is the main parking area for the facility and contains the security guard house. The Tank Farm area is a high use area and the location of many underground pipes and utilities. A large portion of this area would require hand excavation.

Cost - Capital costs for excavation are moderate but could increase significantly with the need for rock and hand excavation. There are no O&M costs associated with excavation. Treatment and/or disposal of the excavated soils, however, would add substantially to the costs.

Screening - Due to significant disturbances associated with excavating the major areas of soil contamination, excavations would need to be carefully staged to minimize interferences to existing operations. Excavation is a potentially viable option for areas where in-situ treatment is questionable and cost-prohibitive.

3.2.1.5 Treatment

Soil Vapor Extraction (In-Situ)

Description - The soil vapor extraction (SVE) process is a technique for the removal of volatile organic compounds (VOCs), and some semi-volatile organic compounds (SVOCs), from the vadose zone. Vacuum blowers supply the motive force, inducing air flow through the soil matrix. The air strips the organics from the soil and carries them to screened extraction wells. Air emissions from the system are typically controlled by adsorption onto activated carbon, thermal destruction (utilizing catalytic oxidation), or condensation by refrigeration.

Effectiveness - The success of the SVE process depends primarily on the vapor pressure of the contaminants and the air permeability of the soil. Because only relatively volatile compounds will undergo a phase change into the soil gas, the vapor pressure is the key contaminant variable with respect to the success of SVE. Compounds with vapor pressures above 0.5 mm Hg have sufficient volatility for effective removal by vacuum extraction (USEPA, Guide for Conducting Treatability Studies Under CERCLA: Soil Vapor Extraction, EPA/540/2-91/019A, September 1991). The compounds/products of concern in the three areas with unsaturated soil contamination (Tank K Area, Tank Farm Area, and the Eastern Parking Lot) are gasoline, Stoddard solvent (nonane, trimethyl benzene isomers), and BTEX. Assuming a soil temperature of 50° F (10°C), the vapor pressures for these contaminants are (see Table 3-3):

	Vapor Pressure (mm Hg)
Gasoline, Weathered	25.0
Stoddard Solvent	1.9

Benzene	45.6
Toluene	12.4
Ethylbenzene	4.0
o-Xylene	2.7
m-Xylene	3.3
p-Xylene	3.6

These vapor pressures indicate that these contaminants are all amendable to SVE. Because the removal of contaminant vapors depends on the ability to induce transport of the vapors through the unsaturated zone, the air permeability of the soil is important in determining whether this method can induce sufficient removal to make the method feasible. In general, if the air permeabilities of the soils are greater than 10^{-6} cm^2, then the site has adequate air permeability. If the air permeabilities are less than 10^{-10} cm^2, SVE may not be feasible. For air permeabilities between these two values, mathematical modeling should be performed to give a clean up time estimate (USEPA, September 1991). The fill material in the Eastern Parking Lot is composed of fine to coarse sand with large quantities of silt; in the Tank K and Tank Farm areas the fill is composed of primarily fine to coarse sand. The air permeability of the soil can be estimated from the hydraulic conductivity of the soil (USEPA, Soil Vapor Extraction Technology: Reference Handbook, EPA/540/2-91/003, February, 1991). The estimated air permeability of the Eastern Parking Lot soils is 3×10^{-7} cm^2 and for the other areas, 4×10^{-6} cm^2. Without actual field testing, the permeability of the soil appears to be marginal; modeling would be required to estimate the expected cleanup time.

The site is already paved which would increase the effectiveness of SVE in two ways: (1) it minimizes infiltration of water from the surface which can reduce available pore space, and (2) it prevents short circuiting thus increasing the system's radius of influence.

The removal of separate phase product by SVE is not a proven effective remedial action.

Implementability - The equipment, materials and labor required for the application of soil vapor extraction are commercially available. Vapors extracted by the SVE process and condensate removal in a vapor/liquid separator would require treatment similar to the groundwater treatment systems evaluated in the next section. Soil from excavating extraction trenches or extraction wells would be treated/disposed with other excavated soils. Due to the shallow depth to groundwater (5 - 6 feet) in the Eastern Parking Lot, horizontal extraction trenches would be more effective than vertical wells. Vertical wells would be used in the Tank K and Tank Farm Areas.

Cost - Capital and O&M costs are expected to be low to moderate when compared to other treatment technologies.

Screening - Because soil vapor extraction is a proven technology for similar contaminants and site conditions as are found at the site, soil vapor extraction will be retained for further evaluation.

Off-Site Incineration (Ex-Situ)

Description - The thermal destruction, or incineration, of contaminated soils and separate phase product is a treatment method that uses high temperature oxidation under controlled conditions to degrade waste materials into by-products that include carbon dioxide, water vapor, inert ash, nitrous oxide, sulfur dioxides and hydrogen chloride gas. The incineration process can be controlled to provide the optimum temperature, residence time, turbulence and oxygen supply required for adequate destruction of organics. Excavation and removal of soil/sediment would be performed and the soil would be transported to a permitted incineration facility.

Effectiveness - Off-site incineration would provide complete and permanent destruction of the organics in the separate phase product and/or soil. There would be potential for adverse impacts to human health and the environment during excavation, and handling and transportation of the soil and separate phase product due to increased potential for exposure to petroleum-contaminated materials.

Implementability - The number of permitted TSD facilities in the local area that can accept the soil and separate phase product for incineration is limited. A trial burn may be required prior to accepting the waste for incineration at these facilities. The labor and materials required to remove the contaminated soil are readily available. Manifests for off-site transportation would be required. Because massive excavation of soils would prove too disruptive to ongoing manufacturing at the site, it would be carefully staged to minimize interference with existing operations.

Cost - Transportation and incineration fees would contribute to a high capital cost for this technology. There are essentially no O&M costs associated with this option since no long-term management would be required.

Screening - Due to limited availability and high associated costs, off-site incineration of excavated material will not be retained for further evaluation.

Low Temperature Thermal Desorption

Description - Soils would be heated in a primary chamber to drive off volatile and low-boiling point semi-volatile compounds, which would later be burned in an afterburner or adsorbed on vapor phase carbon. The process would consist of a soil conveying system, a thermal processor, an afterburner, and possibly a heat recovery system. A hot oil screw conveyor has been previously proposed and field tested as a means of thermal processing. The indirect heat transfer fluid (hot oil) would circulate through a trough jacket. The oil would be heated in the screw conveyor (primary chamber) with an oil heating system which would be hot enough to volatilize the contaminants in the soil.

In the low-temperature thermal desorption soil treatment process, the soils/sediments would only be heated, rather than combusted as in a high temperature thermal process (i.e. incineration). In this method the soil is heated to approximately 400 - 600°F in the primary chamber causing volatization of contaminants and all of the combustion occurs in the secondary combustion chamber (the after burner) where off-gases from the primary chamber are destroyed. In a high temperature process the primary combustion chamber may be operated at temperatures in excess of 1,800°F and the secondary combustion chamber may be operated at approximately 2,200°F.

Effectiveness - For a given organic contaminant it is important to determine whether low temperature treatment will be effective. To volatilize the organic contaminant, the primary chamber temperature should be significantly higher than the boiling point of the compound. The boiling points of the compounds of concern are (see Table 3-3) as follows. Although no analytical data indicated any chlorinated compounds in the unsaturated zone, the boiling points of the chlorinated organics detected in the soil gas data have been indicated to assess applicability of thermal desorption if they are found in the soil.

Soil Contaminant	Boiling Point (°F)
Gasoline	80 - 420
Stoddard Solvent	300 - 400
Benzene	176
Toluene	231
Ethylbenzene	277
o-Xylene	292
m-Xylene	282
p-Xylene	281
Tetrachloroethene	250
Trichloroethene	189
Vinyl chloride	8
Sediment Contaminant	
Bis(2-ethylhexyl) phthalate	725

Based upon the boiling point data, low temperature thermal desorption would be effective in removing the petroleum related contaminants from soils in the Tank K, Tank Farm, and Eastern Parking Lot areas. Because of fairly high boiling points, thermal desorption would not be effective in removing phthalates from contaminated sediments. However, the concentration of this compound in the sediment does not exceed cleanup levels. Low temperature thermal desorption can handle significantly higher levels of VOCs compared to asphalt batching. For a facility in New Hampshire, the acceptance levels are less than 30,000 ppm BTEX and less than 100 ppm chlorinated compounds.

Implementability - The services for low temperature desorption are limited but are available for both on- and off-site treatment. Low temperature treatment does not have as much proven field experience as high temperature treatment but the amount of field experience with these units is rapidly growing.

Cost - The treatment costs for low temperature thermal desorption systems are generally higher when compared to other ex-situ treatment processes such as asphalt batching. However, the treated soil can be used as backfill which is not the case with asphalt batching and reduces overall capital costs to those comparable with asphalt batching.

Screening - Because low temperature thermal desorption effectively removes the compounds of concern (namely, stoddard solvent, and BTEX) and may be more cost effective than off-site incineration, it will be retained for further evaluation.

Ex-Situ Soil Washing

Description - Soil washing is a physical-chemical process in which contaminants in excavated soils are transported to a liquid (surfactant/water solution) in an above-ground treatment system. The excavated soils and surfactants are mixed and agitated. After sufficient mixing, the contaminant/aqueous solution is removed from the soil. The transfer of contaminants occurs by dissolution, chelation or shearing of the contaminants bound to the soil matrix through the application of an extraction fluid. Chelating agents (e.g. ethylenediaminetetraacetic acid [EDTA]) are commonly used for the extraction of heavy metals, binding metal ions so that insoluble metal salts cannot form, but rather forcing the chelating agent/metal ion complex to go into solution.

Effectiveness - Soil washing is a potentially useful remedial technology for removing petroleum contaminants. However, its effectiveness may be limited due to the need to emulsify the separate phase product to provide efficient removal from soils. Thus, treatability testing would be required to determine expected removal efficiencies and select optimal surfactant/water solutions and process options to be used. In addition, the majority of soil in the unsaturated zone consist of fill material which is classified as a silty sand. These silty soils may not be amendable for the soil washing technique since interactions between soil surface and pollutants may retard mobility of contaminants.

Implementability - This emerging technology shows promise but has yet to be used routinely in the field. Currently, there is a limited availability of the necessary equipment and labor to implement this process. Since soil washing would be performed on-site, no off-site TSD facilities or permits would be required. Regulatory approval would be required if replacement of the treated soils on-site were to be considered. A treatment system for the spent aqueous solution is also required. Surfactant addition makes water treatment difficult, and would likely require ultrafiltration.

Cost - Capital and O&M costs are expected to be high, as there is limited availability of sources. O&M costs include purchase of the surfactant and provision for required treatment of aqueous solutions.

Screening - Because of limited field experience, the need for treatability testing, the requirement for additional water treatment which is dissimilar to technologies anticipated for contaminated groundwater, and the high cost ($100 - $125/ton), soil washing will be eliminated from further consideration.

Thickening/Dewatering (Ex-Situ)

Description - Thickening/dewatering is a procedure used to increase the solids content of soil/sediment by removing a portion of the liquid fraction by such unit processes as centrifugation, filtration or gravity thickening. Some of the excavated subsurface soils and the wetland sediment are saturated and will therefore have a high moisture content. These soils may therefore require thickening/dewatering prior to implementing other response actions.

Effectiveness - Thickening/dewatering technologies have been used successfully in wastewater treatment facilities for many years. However, the specific thickening/dewatering chemicals and polymers for the site soils would have to be determined by laboratory studies on the particular waste streams. There are minimal risks to human health and the environment if proper handling and disposal options for the soils and supernatant (groundwater) are implemented.

Implementability - The process is implementable for dewatering of subsurface soils and sediments. The equipment and labor are readily available. If implemented this process option would be part of a treatment train for the subsurface soils. The supernatant generated in the removal and treatment of these soils would require further treatment.

Cost - Relative capital and O&M costs for this process option are expected to be moderate.

Screening - Since thickening/dewatering of subsurface soils/sediment could significantly reduce their weight and/or volumes, this technology is retained, for possible inclusion in the development of remedial alternatives.

Asphalt Batching (Ex-Situ)

Description - Asphalt batching consists of combining soil contaminated with petroleum distillates (gasoline, kerosene, fuel oils, Stoddard solvent, etc.) with the residue of the distillation process (asphalt) to form a chemically stable material. As these substances are all mutually miscible, the process is similar to dissolving the contaminant in the asphalt (stabilization) while simultaneously using the asphalt to produce paving products (solidification).

Asphalt can be softened in three ways: (1) hot top (adding heat which softens the material to the point where it will coat rock), (2) cold patch (making a mixture of the hard asphalt and solvent (gasoline, kerosene, diesel), and (3) cold mix (emulsifying the asphalt with a water-surfactant solution). The hot top process results in some volatilized contaminants. Since the cold patch is made from solvents, the solvents are leached which adds contaminants to the environment rather than removes them. In the cold mix process, asphalt is emulsified, mixed at ambient temperatures with the contaminated soil, and, upon curing, releases water.

Effectiveness - The process has been used successfully on soils contaminated with gasoline, fuel oil, jet fuel, and waste oil. Current DEP regulations allow only virgin petroleum product contamination to be recycled off site. As indicated in the guidelines below for on-site asphalt batching, the petroleum can have a low level of contamination (i.e., chlorinated VOCs.) Tests performed by one Massachusetts vendor (TCLP extraction) on the final product indicate no TPH in the leachate. Asphalt batching does not reduce the volumes of contamination but does significantly reduce mobility. The transfer of contaminants from the unsaturated soils and separate phase product to groundwater or air would effectively be eliminated. As the chemical process is essentially the dissolution of the contaminants into the asphalt, there is a level of contamination above which the contamination will not effectively bond. For the on-site process of a Massachusetts firm, the following guidelines are given for acceptance of soils for their on-site process:

TPH	$\leq$ 60,000 ppm
VOC	$\leq$ 10 ppm BTEX
Halogenated VOCs	$\leq$ 5 ppm

Metals - Total (As, Ba, Cd, Cr, Pb)	≤ 10 times background
PCB	5 ppm

These acceptance criteria guidelines represent averages over the stockpile. These values are similar to acceptance requirements at off-site facilities with the exception that halogenated VOCs (HVOC) are not permissible at off-site facilities. For a facility in Rhode Island, BTEX levels of up to 1,000 ppm can be accepted. The maximum TPH, BTEX, and HVOC concentration encountered on-site are as follows (Wehran, November 1991):

	TPH(mg/kg)	BTEX (mg/kg)	HVOC (mg/kg)
Tank K Area (WE-2)	6,300	2,442	ND
Tank Farm Area (B-16)	11,000	32.1	1.6
Eastern Parking Lot (B-2)	26,000	1.36	ND

Based on these concentrations, the only potential problem is the BTEX levels in the Tank K area would not meet the guidelines for on-site asphalt batching. Given that separate phase product was detected at WE-2, the average concentration excavated from this area would likely be significantly lower. Analytical testing has not been performed on the contaminated soils for heavy metals or PCBs but these are not anticipated to be a problem. Testing by a Massachusetts vendor has also shown the process can effectively handle up to 140 ppm of PAHs. The maximum concentration in the wetland sediments was 6.2 mg/kg.

Implementability - The decision to transport soils to an off-site recycling facility as opposed to on-site recycling will be decided largely on an economic basis. The cost and liability of transporting the soil needs to be considered versus the cost of mobilizing a treatment system and providing the same services on-site. Both options are readily available in New England. In general, with greater soil volumes, the off-site treatment alternative becomes less economically attractive relative to on-site treatment. If a soil storage facility is constructed, then small batches of soil could be stored and processed at one time. The minimum quantity of soil for on-site treatment is approximately 1,000 tons; with typical applications in the range of 2,000-5,000 tons. The estimated quantities of contaminated soil in the Eastern Parking Lot and Tank K area are approximately 9,400 tons and 11,500 tons, respectively. These quantities would make on-site treatment economical. However, it may be difficult to implement asphalt batching over these areas without significantly disrupting present operations. Also these large quantities would dictate raising the level of the existing parking lot significantly (8 inches - 18 inches).

Cost - The capital costs for asphalt emulsion stabilization would be moderate and there would not be any O&M costs.

Screening - Asphalt batching will be retained as a treatment process for the soils/sediments which are excavated.

Ex-Situ Biological (Aerobic)

Description - Bioremediation is a process by which organic contaminants can be degraded by the action of microorganisms. Three general mechanisms are used by microbes to catabolize (breakdown to simpler substances) hydrocarbons: (1) aerobic respiration, (2) anaerobic respiration, and (3) fermentation. Aerobic respiration is typically the most rapid and most complete degradation process, and avoids problematic end products (e.g., hydrogen sulfide) that result from anaerobic respiration. For petroleum hydrocarbons (gasoline, Stoddard solvent, BTEX compounds) under ideal conditions, the end products are carbon dioxide, water and biomass. Under less than ideal conditions (i.e. inadequate oxygen supply, lack of nutrients, etc.), less complete degradation may take place resulting in only partial breakdown of hydrocarbons.

Effectiveness - The factors affecting the appropriateness and potential effectiveness of bioremediation for a particular site may be divided into broad categories: (1) the susceptibility of the contaminants to biodegradation; and (2) the various environmental factors at the site (e.g. available oxygen concentration, appropriate levels of macro- and micro-nutrients, degree of water saturation, soil temperature, etc.). The types of petroleum products which have been successfully treated by biological degradation include gasoline, jet fuel, #2, #4, and #6 heating fuels, diesel fuel, waste oil, lubricating oil and cutting oil. The biodegradability of Stoddard solvent is questionable. As a first approximation Stoddard solvent is composed of 85% nonane and 15% trimethylbenzenes. It is a mixture of n-alkanes, cycloakanes, alkylaromatics and aromatic compounds in the C_9-C_{11} range. Lyman (Handbook of Chemical Property Estimation Methods, American Chemical Society, 1990) indicated that microbes can grow on normal alkanes from n-octane to n-eicosane (C_8-C_{20}) but not on n-heptane to methane (C_7-C_1). Another source (USEPA, Cleanup of

Releases from Petroleum USTs: Selected Technologies, PB88-241856, April 1988) indicated that n-alkanes, n-alkylaromatic and aromatic compounds of the C_{10}-C_{22} range, are the least toxic to micro-organisms and the most readily degradable compounds found in petroleum products. Compounds of this type, in the C_5-C_9 range, tend to be easily removed by volatilization and can be toxic to micro-organisms in high concentrations. It is not anticipated that the PAHs (benzo(a)anthrancene, chrysene, fluoranthene or pyrene) detected in the sediments would biodegrade, in that no significant oxidation of PAHs containing more than three rings occurs (Lyman, 1990). Soil bacteria have also demonstrated the ability to degrade halogenated organic compounds such as trichloroethylene (TCE) and dichloroethane (DCA). The environmental factors can be more easily maintained in an ex-situ system versus an in-situ bioremediation process.

Implementability - To implement ex-situ bioremediation, a treatment and storage area would need to be constructed. Soil would need to be stored in a manner that would minimize the migration of contaminants to the air and surrounding soils. Since the durations for bioremediation is relatively long (possibly 2 - 3 years), this form of treatment would require considerably more storage area than other technologies under consideration. Disruption of current site use would be more extensive and would continue for a longer period of time than would occur with other technologies.

Cost - The capital cost for ex-situ bioremediation is moderate and the O&M costs are moderate to high depending on the length of time required to attain desired treatment.

Screening - Due to its questionable effectiveness with Stoddard solvent, the need for a permanent storage area for soils on-site, and extended disruption to use of site, ex-situ bioremediation will be eliminated from further consideration.

3.2.1.6 Disposal

Off-Site TSD Facility

Description - Off-site disposal entails transporting excavated materials by a licensed waste transporter to an approved treatment, storage and disposal (TSD) facility beyond the site boundaries. This activity would apply to excavated soils and possibly to any sludges generated during a treatment process.

Effectiveness - No reduction in contaminant toxicity or volume would result from off-site disposal; contaminants in the soil would simply be transferred to another location, leaving potential for future release to the environment. Thus, disposal would be an effective short-term action but its long-term reliability is questionable. In the anaerobic environment of the landfill, no significant degradation of the petroleum constituents in the soil occurs, so, though the soil has been removed and disposed of, it has not been effectively treated. Off-site disposal of materials without treatment to reduce mobility, toxicity or volume is not a preferred remedy and should be minimized.

Implementability - The equipment and labor required to transport contaminated soils is readily available. Capacities at TSD facilities are limited, but expected to be available. Martin Marietta could be held liable for remediation costs should there be a failure of a landfill that has accepted contaminated soils from the site.

Cost - Capital costs are expected to be high for off-site disposal of contaminated soils; O&M costs are minimal, given that the wastes are removed from the site.

Screening - The landfill disposal option will be retained for further evaluation to address the limited soils from trench excavations and sludges generated in the treatment of groundwater.

On-Site Reuse

Description - On-site reuse entails using the treated excavated soils either as backfill (i.e. after thermal desorption) or as paving material (i.e., asphalt batching).

Effectiveness - In the case of soil treated by thermal desorption , the residuals in the soil are below cleanup levels and Land Disposal Restrictions and can be effectively used as backfill for excavations. This reduces the requirement for transporting clean fill material to the site. In the case of asphalt batching where the hazardous material is stabilized but not removed, the material effectively meets Land Disposal Restrictions for TCLP (Toxicity Characteristic Leachate Procedure) and can be used for on-site paving. It does not reduce the need for transporting clean fill material to the site.

Implementability - The equipment and labor for on-site reuse (backfill or paving) is readily available. No TSD facilities are required. As noted above, reused soil must meet Land Disposal Restriction (40 CFR Part 268). Cold mix asphalt emulsion can only be placed above water table. A surface wearing course must be placed over the asphalt recycled soils.

Cost - Capital costs are expected to be low for on-site reuse. Long-term groundwater monitoring may be required downgradient of paving material which could result in low O&M costs.

Screening - In that both thermal desorption and asphalt batching have been retained and potential quantities could justify on-site treatment, on-site reuse of treated soils will be retained for further evaluation.

3.2.2 Groundwater

3.2.2.1 No Action

Description - The No Action general response action implies that no further remedial actions would be conducted beyond on-going groundwater monitoring. Under this alternative, no remedial action would be undertaken to address groundwater contamination in the overburden and bedrock aquifers at the 50 Fordham Road property and wetlands north of Concord Street.

Effectiveness - Since no further remedial action would be undertaken, implementation of this alternative would cause no further impact on human health and the environment. The No Action general response action would not achieve the remedial action objectives. Although the cleanup objectives would not be achieved in the IWPA, the groundwater treatment systems installed (and funded by GE Aerospace) at the Town of Reading 82-20 and Town Forest Wells addresses potential contaminants entering these wells, thereby eliminating potential exposure to public water supplies.

Implementation - The No Action general response action can be easily implemented. Potential constraints such as availability of TSD facilities, the need for permits, and the availability of equipment and labor are not of concern.

Cost - There are no capital costs associated with the No Action general response action. Long term O&M costs for monitoring are expected to be moderate.

Screening - No Action would not meet the remedial action objectives of attaining cleanup levels. However, No Action will be retained and considered a remedial action alternative to serve as a baseline for comparison with other alternatives in Section 5.0.

3.2.2.2 Containment

The only containment technology which was retained is sheet pile walls. Sheet pile walls are discussed under Section 3.2.1.3. Sheet pile walls are retained as a potential measure for reducing flow (uncontaminated groundwater) to a subsurface drain (see Section 3.2.2.4).

3.2.2.3 Collection

Extraction Wells

Description - Groundwater pumping techniques involve the active management of groundwater in order to contain and/or remove a plume. Types of wells used in the management of contaminated groundwater include well points, suction wells, ejector wells and shallow to deep wells. The selection of the appropriate well type depends upon the depth and nature of contamination and the hydrologic and geologic characteristics of the aquifer.

Effectiveness - Use of extraction wells is best suited to situations where contaminants are miscible and/or move readily with water; where the hydraulic gradient is steep and the hydraulic conductivity high; and where quick removal is not necessary. The major contaminants (BTEX and chlorinated hydrocarbons) are miscible and quick removal is not a requirement of the system.

Well point systems are effective in almost any hydraulic situation. They are suited for shallow aquifers where extraction is not needed below more than 22 feet. Beyond this depth, suction lifting is ineffective. For extraction depths greater than 20 feet, deep wells and ejector wells are used. Deep well systems are better suited to homogenous aquifers with high hydraulic conductivities and where large volumes of water may be pumped. Ejector wells perform better than deep wells in heterogenous aquifers with low hydraulic conductivities. A problem with ejector systems is that they are inefficient and are sensitive to constituents in the groundwater which may cause chemical precipitates and well clogging.

Implementability - The installation and pumping equipment for extraction wells is readily available.

Cost - The capital and O&M costs for extraction wells are relatively low.

Screening - In that water must be collected from different strata, including deep overburden and bedrock, extraction wells will be retained for further evaluation.

Subsurface Drains

Description - Subsurface drains include any type of buried conduit used to convey and collect aqueous discharges by gravity flow. Subsurface drains essentially function like a horizontal extraction well. They create a continuous zone of influence in which groundwater and/or separate phase product within this zone flow towards the drain. The major components of a subsurface drainage system are:

- Drain pipe or gravel bed - for conveying flow to a wet well or sump;
- Envelope - for conveying flow from the aquifer to the drain pipe or bed;
- Filter - for preventing fine particles from clogging system;
- Backfill - to restore surface grade and prevent ponding; and
- Sumps - manholes or wet wells to collect flow and pump the discharge to a treatment plant.

Effectiveness - For shallow contamination problems (e.g. separate phase product in the Eastern Parking Lot), drains can be more effective than vertical recovery wells, particularly in strata with low or variable hydraulic conductivity. Under these conditions, it would be difficult to design and it would be cost prohibitive to operate an extensive number of recovery wells to maintain a continuous hydraulic boundary. Furthermore, to achieve a significant radius of influence with groundwater depression pumps would require extensive drawdown which would in turn cause significant smearing of product in the soil column.

The most widespread use of subsurface drains is to intercept a plume hydraulically downgradient from its source. These interceptor drains are frequently used together with a sheet pile wall (see Section 3.2.1.3). The primary reason for the interceptor drain/barrier wall combination is to reduce the volume of clean water which would be collected from downstream of the contaminated plume. This combination could be effective in the Tank K Area and may be considered for other areas of contamination as well.

Implementability - Trench excavation to depths of 10 feet or more, if appropriate equipment is used, should be easily implemented. Extensive hard rock excavation and dewatering would not be required. The excavated soil would require treatment or disposal. The equipment and labor for installing subsurface drains is readily available. Safety of field workers is more of a concern with subsurface drains than wells. Little or no difficulty is expected from regulatory agencies in getting this type of groundwater/product extraction system approved.

Cost - Installation costs depend primarily on the depth of excavation/stability of soils, extent of rock blasting and/or removal required, and groundwater infiltration rates. Capital costs associated with installation of subsurface drains are typically much higher than those associated with well systems. However, O&M costs associated with drains are generally lower than with wells.

Screening - Based on the potential effectiveness for collecting Stoddard solvent in the Eastern Parking Lot and for intercepting the contaminated plume in the Tank K Area, subsurface drains will be retained for further evaluation.

3.2.2.4 Treatment

Air Stripping

Description - Air stripping is a mass transfer process in which volatile contaminants in the liquid phase are transferred into the gaseous phase. Air stripping of contaminated groundwater is governed by the equilibrium relationship of Henry's Law. Henry's Law states that the partial pressure of a gas or volatile compound in the air above a dilute aqueous solution is directly proportional to its concentration in the solution. Mathematically,

$$P_a = (H_a)(X_a)$$

Where:

P_a = Partial pressure of compound A in air (atm)

H_a = Henry's Law constant for compound A ($atm \cdot m^3/mol$)

X_a = Molar concentration of compound A in solution (mol/m^3)

Three general types of air strippers are employed in treating groundwater: packed towers, tray aerators and diffused aeration. Transfer of volatile organics is most efficiently accomplished in a packed tower, with countercurrent flow of air and water. This configuration provides a high level of turbulence and a very large surface area for mass transfer. A packed-tower air stripper consists of the tower shell; packing materials; tower internals including the liquid distributor and redistributor, packing support plates, and demister pad; pumps and piping for the water; and a blower to provide air to the base of the tower. The key design variables for packed towers are the liquid loading rate, air-to water ratio, the packing height, and the characteristics of the tower packing. Typical towers range from 1 to 12 feet in diameter and, as a general rule, 5 to 50 feet in packing height. Liquid loading rates are generally from 5 to 30 gpm/ft^2 and volumetric air-to-water ratios may be as low as 10:1 or as high as 300:1.

The shallow tray process uses forced draft, countercurrent air stripping through baffled aeration trays to remove VOCs from water. Contaminated water is sprayed into an inlet chamber through a coarse mist spray nozzle and then flows along the baffled aeration tray. Air is blown through small diameter holes in the trays, forms a froth of bubbles generating a large mass transfer surface area where the contaminants are volatilized. The necessary residence of contact time to reach volatilization is achieved through tray size, number of trays and air-to-water ratio selection. The shallow tray aerator employs a significantly higher air-to-water ratio than is used with the packed tower because the process is less efficient.

In diffused aeration, air is compressed and released near the bottom of a treatment tank through bubble diffusers. The purpose of the diffusers is to distribute the air uniformly through the water cross section and to produce the desired air bubble size. As the bubbles rise, mass transfer of the contaminant occurs across the water-air interface until the bubbles reach the surface or become saturated with the contaminant. The removal efficiency of diffused aeration for stripping organics can be improved by decreasing the bubble size, increasing water depth, increasing detention time, and increasing the volumetric air-to water ratio.

<u>Effectiveness</u> - Air stripping is used to remove dissolved volatile organic compounds from contaminated groundwater and is most effective on compounds with Henry's Law constants greater than 1.0 x 10^{-4} atm.m^3/mole. The Henry's Law constants for the contaminants of concern at this site are (see Table 3-3):

Benzene	2.88 x 10^{-3}
Bromomethane	9.12 x 10^{-3}
1,1 Dichloroethane	2.29 x 10^{-3}
1,1 Dichloroethene	1.55 x 10^{-2}
cis-1,2-Dichloroethene	3.60 x 10^{-3}
trans-1,3-Dichloropropene	4.90 x 10^{-4}
Ethylbenzene	3.99 x 10^{-3}

Methylene Chloride	1.05×10^{-3}
1,1,2,2 Tetrachloroethane	1.68×10^{-4}
Tetrachloroethene	1.12×10^{-2}
Toluene	4.09×10^{-3}
Trichloroethene	5.14×10^{-3}
Vinyl Chloride	1.52×10^{-1}
o-Xylene	2.12×10^{-3}
m-Xylene	2.86×10^{-3}
p-Xylene	3.10×10^{-3}
Bis (2-ethylhexyl)phthalate	3.60×10^{-7}
Gasoline	0.74
Stoddard solvent	0.12
Nonane	4.8
1,2,4-Trimethylbenzene	2.50×10^{-3}
1,3,5-Trimethylbenzene	2.40×10^{-3}

These values indicate that air stripping is a well suited and effective method for removing those contaminants of concern found at the site, with the exception of bis(2-ethylhexyl) phthalate.

A properly designed and operated packed tower air stripper or shallow tray aerator can achieve greater than 99 percent removal of volatile organics from water. Diffused aeration system would only achieve removal efficiencies of 90 percent or less.

Implementability - The materials and labor needed to install an air stripper are readily available. Prior to the waste stream entering the air stripper, pretreatment should be considered. These measures include: (1) separation of separate phase product (gasoline or Stoddard solvent), (2) removal of suspended solids, and (3) removal of dissolved metals (iron and manganese). Dissolved iron and manganese have been detected as high as 39 mg/l and 5.3 mg/l, respectively. Total concentrations of these metals have been detected at 340 mg/l and 6.5 mg/l. Oxygen from the air promotes the conversion of iron to oxidation states that are insoluble in water. These insoluble iron oxides precipitate out of the water and crystals attach to any available surface. As soon as a crystal attaches itself, it becomes a "seeding" site for other crystals to adhere and grow. A complicating factor is that the heavily aerated water is also an excellent medium for bacterial growth. Bacterial colonies in the water attach themselves to the packing and provide numerous sites for inorganic deposition and vice-versa. Some forms of bacterial use iron and manganese as nutrients. Consequently, the packing material will require periodic cleaning (e.g., phosphoric or nitric acid). Residuals from an air stripping process include the treated effluent and contaminated off-gas. Treatment of the off-gas will be required to meet regulatory requirements and this may be accomplished through vapor phase carbon or catalytic oxidation.

The packed tower, tray aeration and diffused aeration systems are well understood technologies. There is a considerable theoretical foundation for these systems and treatability studies are generally not required.

Cost - The cost for installing an air stripper is low, but overall system costs will be moderate if air emission controls are required. Because of the need for off-gas treatment, O&M costs range from moderate to high. These costs are also affected by the frequency of cleaning that is required. Due to the significantly higher power costs for VOC removal by diffused aeration and tray aerators, only packed towers will be considered.

Screening - This option is applicable to the treatment of volatile organic compounds in the groundwater and is therefore retained for further evaluation.

Carbon Adsorption

Description - The process of adsorption onto activated carbon involves contacting a waste stream with carbon, usually by flow through a series of packed bed reactors. The activated carbon selectively adsorbs contaminants by a surface attraction phenomenon in which organic molecules are attracted to the internal pores of the carbon granules.

Once the micropore surfaces are saturated with organics, the carbon is "spent" and must be replaced with virgin carbon or removed, thermally regenerated, and replaced. The time to reach "breakthrough" or exhaustion is the single most critical operating parameter.

Effectiveness - Activated carbon is a well developed technology which is widely used in the treatment of organic waste streams. Activated carbon is an effective and reliable means of removing low solubility and non-polar organics. Adsorption capacities of greater than or equal to 50 mg of contaminant per gram of carbon on influent concentrations of

1,000 µg/l are usually required for economical operations. The adsorption capacities for the compounds of concern are as follows (see Table 3-3):

Compound	Adsorption Capacity mg Compound/g carbon
Benzene	49
Bromomethane	-
1,1 Dichloroethane	1.8
1,1 Dicholorethene	4.9
cis-1,2 Dichloroethene	12
trans-1,3 Dichloropropene	-
Ethylbenzene	175
Methylene Chloride	1.3
1,1,2,2 Tetrachlorethane	11
Tetrachlorethene	51
Toluene	100
Trichloroethene	28
Vinyl Chloride	0.002
Xylenes	174 - 230
Bis (2-ethylhexyl) phthalate	11,300

As indicated low molecular weight, polar compounds (halogenated hydrocarbons) are not well adsorbed. High molecular weight, non-polar compounds such as aromatics and phthalates are readily adsorbed. No data was available for the constituents of Stoddard solvent, nonane and trimethyl benzene. As noted, adsorption capacity is a function of molecular size and polarity. Nonane is a high molecular weight, non-polar compound and would be expected to be adsorbed effectively. The effectiveness of adsorbing trimethyl benzene isomers can be evaluated by comparing them to BTEX compounds. The adsorption capacity of BTEX compounds increases with decreased solubility:

Compound	Solubility (mg/l)	Adsorption Capacity (mg/g)
Benzene	1730	49
Toluene	448	100

Ethylbenzene	171	175
Xylenes	120-133	174-230

The trimethyl benzene (TMB) isomers have lower solubilities (29.9 - 72.6 mg/l) than BTEX compounds. The dipole moment of TMBs (0 - 0.8) are similar to those of BTEX compounds (0 - 0.693) so that polarity is not a significant variable. Both sets of compounds are relatively non-polar. Based on this information, it is anticipated that trimethylbenzenes will have adsorption capacities equal to or greater than that of xylenes.

Based on the adsorption capacities described above, carbon adsorption will be cost effective for some compounds, but not for others. The overall effectiveness will be dependent upon the contaminants present and influent concentrations.

Pretreatment is required for petroleum hydrocarbons, suspended solids and dissolved metals. Concentrations of oil and grease in the influent should be limited to 10 ppm. Suspended solids should be less than 50 ppm to prevent clogging the column. Groundwaters containing significant (greater than 5 mg/l) levels of iron and manganese must be treated to remove these compounds before GAC treatment. If the iron and manganese are not removed prior to GAC treatment, they will precipitate onto the carbon, clog the carbon pores, cause rapid head loss, and eventually prevent flow through the carbon. Iron and manganese removal will be required at the site because levels of dissolved iron and manganese have been detected as high as 39 mg/l and 5.3 mg/l, respectively.

<u>Implementation</u> - Activated carbon is easily implemented and the equipment is readily available. The most important maintenance consideration associated with activated carbon treatment is the disposal or regeneration of spent carbon for reuse.

<u>Cost</u> - The capital cost and O&M costs for an activated carbon treatment system are high.

<u>Screening</u> - In that activated carbon can remove the contaminants present in the groundwater to required levels, it will be retained for further consideration, possibly a polishing step to air stripping.

Chemical Oxidation

<u>Description</u> - Liquid phase chemical oxidation is a process in which the oxidation state of a substance, (i.e., loss of electrons) is increased. Oxidizing agents most often supply

oxygen during the oxidation process, however other electron acceptors can be utilized. Some of the most effective oxidants include: fluorine, hydroxyl radical, ozone and hydrogen peroxide.

With the exception of fluorine, hydroxyl radicals have the highest oxidation potential for any of the commonly used oxidants. When either hydrogen peroxide (H_20_2) or ozone is catalyzed with ultraviolet light (UV) at wavelengths in the range of 260 to 400 nanometers, hydroxyl radicals are formed which then react with the organic contaminant. Under UV radiation, the H_2O_2 molecule converts to two highly reactive hydroxyl radicals; the ozone forms only one hydroxyl radical.

Neither H_2O_2 nor ozone contain metals or halogens which can lead to undesirable by-products during the organic oxidation process. H_2O_2 has certain inherent advantages over ozone. H_2O_2 is supplied commercially as an easily handled liquid which has infinite solubility in water. Ozone is a toxic gas with limited water solubility. The water solubility of H_2O_2 simplifies the reactor design in terms of oxidant addition, mixing of the reactants and elimination of fugitive toxic gas. Typically, H_2O_2 storage and feed systems are relatively inexpensive compared to ozone generation and feed equipment. For these reasons, only the UV-H_2O_2 process will be considered.

Effectiveness - The UV light-catalyzed H_2O_2 process has been demonstrated to be effective for the destruction of many VOCs. The UV/H_2O_2 oxidation process is relatively effective for destroying aromatic hydrocarbons (e.g. benzene) and organic compounds that have double or triple carbon-carbon bonds (e.g., vinyl chloride or trichloroethene [TCE]). However, saturated organics such as dichloroethane (DCA) are less susceptible to attack by hydroxyl radicals. The majority of compounds of concern at the site fall into the first two categories; aromatics (benzene, toluene, ethylbenzene, xylene isomers, trimethylbenzene isomers) and halogenated olefins (tetrachloroethene, trichloroethene, cis-1,2,-dichloroethene, vinyl chloride, trans-1,3-dichloropropene).

The saturated compounds are nonane (Stoddard solvent), the other alkanes in gasoline, halogenated alkanes (bromoform, 1,1 dichloroethane, methylene chloride, and 1,1,2,2 tetrachloroethane) and bis(2 ethyl hexyl)phthalate. These compounds have been successfully treated but will require greater oxidation times. The alkanes associated with gasoline and Stoddard solvent have low solubilities and will primarily be removed through gravity separation. Typically there are no off-gases produced from the UV-H_2O_2 process which require further treatment. Due to the low level of chlorinated VOCs detected in site groundwater, concentrations of chlorine in the effluent as chloride and/or hydrochloric acid, would not exceed discharge criteria for chlorides.

Implementability - The chemicals, equipment and services needed to implement this process are readily available. The treatment system cannot handle turbid water. Therefore, pretreatment for metals/solids would likely be required to prevent fouling of the unit and to assure that discharge standards are attained.

Cost - The capital costs for installing a chemical oxidation system are moderate. Moderate to high O&M costs are associated with this option.

Screening - This option is potentially applicable for groundwater treatment. The capital and O&M costs for this treatment option are significantly higher than for air stripping. This would not be the case, however, if air emissions from the air stripper are controlled. Since treatment of air stripper off-gas is anticipated, the two technologies are comparable in terms of cost. Therefore, chemical oxidation is retained for further evaluation.

Chemical Precipitation

Description - Precipitation is a physicochemical process whereby a portion of a substance in solution is transformed into a solid phase. It is based on alteration of the chemical equilibrium relationships affecting the solubility of inorganic species. Removal of metals as hydroxides is the most common precipitation application in wastewater. Lime or caustic are added in a rapid mixing tank along with flocculating agents. The groundwater flows to a flocculation chamber in which adequate mixing and retention time is provided for agglomeration of precipitated particles. Agglomerated particles are separated from the liquid phase by settling in a sedimentation chamber and/or by other physical processes such as filtration.

Effectiveness - Precipitation is applicable to the removal of most metals from groundwater including iron and manganese. Also, certain anionic species such as phosphate can be removed by precipitation. The phosphorus levels in the groundwater samples ranged from <0.01 - 27 mg/l. Therefore, a discharge of treated effluent to the wetlands may require phosphorus removal. If lime is used as a precipitant, the calcium ion reacts with phosphate ion in the presence of hydroxyl ions to form hydroxyapatite. The solubility of hydroxyapatite is so low that at a pH as low as 9.0 (the pH used for iron and manganese removal), a large fraction of the phosphorus can be removed. The performance and reliability of precipitation and flocculation depends greatly on the variability of the composition of the waste stream being retreated. Therefore, the use of equalization facilities may be required. Precipitation is not an effective process for the removal of organics.

Implementability - The equipment is readily available and easy to operate. Precipitation and flocculation can be easily integrated into more complex treatment systems. The process produces a sludge which will require dewatering and disposal. Based on heavy metal concentrations in the groundwater, it is not anticipated that the sludge will be hazardous but further evaluation is required.

Cost - The capital costs for a chemical precipitation system are moderate and O&M cost (assuming non-hazardous sludge) are moderate.

Screening - Because the three primary organic treatment processes (air stripping, carbon adsorption and chemical oxidation) require iron and manganese removal, chemical precipitation will be retained for further evaluation.

Filtration

Description - Filtration can be employed for the removal of suspended solids from a liquid by passage of the fluid through a bed of granular material, or it can be used to dewater sludges by high pressure, or by gravity. Granular media filters (typically sand and anthracite) remove suspended solids through straining, physical adsorption and coagulation-flocculation. In order to prevent plugging, the filter is backwashed at a high velocity to dislodge the particles. The backwash water contains high concentrations of solids and requires further treatment.

Various filtration methods have been employed to dewater sludges. The most widely used method for hydroxide sludges is the chamber pressure filter (filter press) which consists of a collection of cloth covered plates arranged in parallel and pressed together by pressures of 100 - 200 psi. As the plates are compressed, filtrate exits through the cloth. The system can be operated in a batch mode and can produce filter cakes in the range of 40 - 50% solids.

Effectiveness - Granular media filtration systems are used on waste streams containing suspended solids in the range of 100 to 200 mg/l or less. The effluent from the chemical precipitation clarifier will have approximately 50 mg/l suspended solids or less. The filtration process will ensure that suspended solids in the influent to subsequent organic treatment processes are less than 10 mg/l.

A filter press will produce a cake which can be landfilled (>20% solids). Filtration is the most effective method for dewatering slurries. The process is generally reliable provided that the sludge is properly conditioned.

Implementability - Filtration equipment for aqueous waste streams is relatively simple, readily available in a wide range of sizes and easy to operate and control. Filtration is also easily integrated with other treatment steps. The backwash will generally contain high concentrations of contaminants and require subsequent treatment.

Filter press equipment is readily available. A dewatered sludge will be produced which requires disposal, and filtrate which will require treatment.

Cost - Capital and O&M costs for aqueous stream filtration are relatively low. The capital and O&M costs for a filter press are moderate.

Screening - Aqueous stream filtration is applicable to ensuring low solids loading to subsequent treatment units and will be retained for further evaluation. Sludge from the chemical precipitation process will require dewatering, therefore, the filter press will also be retained for further evaluation.

Gravity Separation/Sedimentation

Description - Gravity separation is a purely physical phenomenon in which oil is permitted to separate from water in a tank. Gravity separators are primarily used to treat two-phased aqueous wastes. Separators are large tanks into which a hydrocarbon and water mixture is pumped. Their main function is to slow the flow of the incoming water and allow gravity separation of the less dense hydrocarbon emulsions. Oil/water separators are composed of two or more chambers. The first is for the deposition of solids, and the second is for the separation of liquids with dissimilar specific gravities and the removal of the lighter liquid from the heavier liquid. Baffles and coalescer packs are frequently installed to provide additional surface areas, which promote oil droplet coalescence.

Effectiveness - It is critical in the design of the system that the volume of the separator tank be at least 10 times the extraction rate of the groundwater. Under optimum conditions, an oil/water separator can reduce the amount of hydrocarbon in water to less than 15 ppm. Both gasoline and Stoddard solvent have relatively low densities (0.73 and 0.75 g/cm^3, respectively) and therefore should be removed effectively. However, a gravity separator will not effectively remove dissolved BTEX compounds associated with gasoline. These components must be removed by subsequent treatment steps.

Implementability - Simple, readily available equipment can be used for gravity separation and operational requirements are minimal. If emulsion-breaking chemicals must be added to promote oil/water separation, laboratory tests should be periodically conducted to ensure adequate dosing. The immiscible liquid (gasoline and Stoddard solvent) will require proper disposal.

Cost - The capital and O&M costs for gravity separators are relatively low.

Screening - In that groundwater will be recovered in three areas with separate phase product (which must be removed prior to subsequent treatment), gravity separation will be retained for further evaluation.

Reverse Osmosis

Description - Osmosis is the spontaneous flow of water from a dilute solution through a semipermeable membrane to a more concentrated solution. Reverse osmosis is the application of sufficient pressure to the concentrated solution to overcome the osmotic pressure and force the net flow of water through the membrane toward the dilute phase. This allows the concentration of impurities to be built up in a circulating system on one side of the membrane while relatively pure water is transported through the membrane. The basic components of a reverse osmosis unit are the membrane, a membrane support structure, a containing vessel, and a high pressure pump.

Effectiveness - Reverse osmosis (RO) is used to reduce the concentration of dissolved solids, both organic and inorganic. In general, good removal can be expected for high molecular weight organics and charged anions and cations. Multivalent ions (e.g. Ca^{2+}, SO_4^{2-}) are treated more effectively than are univalent ions (Na^+, Cl^-). Recent advances in membrane technology have made it possible to remove such low molecular weight organics as alcohols, ketones, amines and aldehydes. Research has shown that removal efficiencies of chlorinated solvents (e.g. trichloroethylene) are initially very high. However, with increasing contact time between the TCE-contaminated groundwater and the membranes, the solvent removal efficiency decreases significantly.

RO units are subject to chemical attack, fouling and plugging. Pretreatment requirements can be extensive. Groundwater must be pretreated to remove oxidizing materials such as iron and manganese salts, to filter out particulates, to adjust pH to a range of 4.0 to 7.5, and to remove oil and grease.

Implementability - The equipment for an RO system is readily available. The pretreatment required is similar to that required by the organic treatment processes (air stripping, carbon adsorption, and chemical oxidation), namely removal of iron and manganese, suspended solids and oil and grease. The volume of reject generated by reverse osmosis is about 10 to 25 percent of feed volume. Provisions must be made to treat or dispose of this concentrate.

Cost - The capital and O&M costs for RO are relatively high.

Screening - Because the dissolved solid concentration of the effluent is not anticipated to exceed the groundwater discharge limitation of 1000 mg/l (existing specific conductance data indicates TDS of 100 - 500 mg/l and the use of lime as precipitant reduces TDS), the RO process will be eliminated from further consideration. ??

Neutralization

Description - Neutralization consists of adding acid or base to a waste stream in order to adjust its pH. To reduce the required volume of the neutralization basin, a mixer is installed to provide more intimate contact between the waste and neutralizing agents, thus speeding up reaction time. The most common neutralizing agents are sulfuric and hydrochloric acid for streams that are basic and sodium hydroxide and lime for streams that are acidic.

Effectiveness - Because the removal of iron and manganese requires a pH (9 - 11) which is above the limits for surface water discharge or groundwater reinjection (6.5 - 8.3), neutralization will be required if precipitation is employed. Sulfuric acid can effectively lower the pH of the effluent below 8.3. The process is reliable provided pH monitoring units are used.

Implementability - Neutralization is a relatively simple treatment process which can be performed using readily available equipment. Because of the corrosivity of the treatment reagents, appropriate materials of construction are needed to provide a reasonable service life for equipment. The use of automatic pH monitoring to regulate feed of neutralizing agents minimizes worker contact with corrosive chemicals.

Cost - Capital costs are low; O&M costs for neutralization are low to moderate.

Screening - Neutralization will be required to meet discharge limits of pH if chemical precipitation is used, therefore, it will be retained for further evaluation.

Catalytic Oxidation

Description - Catalytic oxidation is a process for treating organics in the gaseous phase (e.g. emissions from SVE or air stripper). Organic materials can ordinarily be burned if they are mixed with air to provide an oxygen content above the 10 - 15% range, have a hydrocarbon concentration above the lower combustible limit, and are heated above an auto-ignition temperature. Flame incineration is often used for abatement of organic emissions when organic materials are present at high concentrations. Thermal incineration of organic materials also can take place when concentrations are well below the lower combustible limit, provided that the temperature is high enough (1600 - 2000°F) and the gases are maintained at the temperature long enough. Catalysts increase the rate of reaction by adsorbing gas molecules on catalytically active sites. Catalytic oxidation operates at temperatures in the 600 - 800°F range requiring much less fuel than thermal incineration.

The catalytic reactor is comprised of a thermal zone and a catalyst zone. The thermal zone is designed to supply catalyst preheat requirements. The catalyst zone includes a distribution and support grid for the catalyst bed.

Effectiveness - Catalytic oxidation is effective on hydrocarbon vapors. Most catalytic oxidizers use platinum or palladium catalysts which lose their activity when exposed to halogenated compounds such as vinyl chloride and dichloroethane. These compounds tend to adsorb strongly on the catalytic surface, and prevent the reactants from finding unoccupied sites. Recently developed catalysts permit the efficient destruction of halogenated compounds.

When high concentrations of chloro-organics are being burned, gaseous HCl is produced as a reaction product and this must be removed from the flue gas by a caustic scrubber.

Implementability - The equipment for catalytic oxidation is readily available. The areas which may employ SVE (especially Tank K) are mainly contaminated with high concentrations of hydrocarbons and the vapor will be highly contaminated. In this situation, catalytic oxidation may have economic advantages over vapor phase carbon.

Cost - The capital and O&M costs are relatively high.

Screening - Because the vapor extracted in soil remediation may be highly contaminated (which will cause vapor phase carbon to be excessively costly) and compounds may be present in the off-gases from an air stripper which are not effectively removed by carbon (e.g., vinyl chloride), catalytic oxidation will be retained for further evaluation.

Vapor Phase Carbon

Description - Vapor phase carbon adsorption involves the transfer of contaminants from a gas (e.g. emissions from an air stripper) to an adsorbent (i.e., activated carbon). Adsorption systems for the treatment of gaseous waste streams generally consist of containerized beds of carbon. The waste stream flows through the bed, leaving behind the contaminants which become sorbed to the carbon. This process continues until the adsorbent material reaches capacity and needs to be replaced or regenerated. Multiple adsorbent beds are often used so that operation can be continuous while spent adsorbent is being processed.

Effectiveness - In cases where treatment of air stripper or vacuum extraction off-gas is desired or required, vapor-phase carbon is the most common treatment. The advantage of using vapor-phase GAC (granular activated carbon) after a stripper (as compared to using liquid-phase GAC and foregoing the stripper) is in the greatly increased adsorption capacity of the GAC in the vapor-phase. By transferring the contamination to the vapor-phase (via air stripping) prior to removal by GAC, the carbon can adsorb much more contaminant. Depending on the chemical in question, the vapor-phase adsorption capacity can range from 3 to 20 times higher than liquid-phase capacity.

In order for vapor-phase carbon to be properly utilized, the off-gas relative humidity must be reduced to below 50 percent. This can be accomplished by heating the air. If the relative humidity is not reduced, the capacity of the carbon is significantly reduced because the water molecules occupy adsorption sites preferentially.

Implementability - The equipment for vapor-phase carbon systems (adsorbers, preheaters) is readily available. Monitoring of the vapor exiting carbon units will be required to determine when breakthrough has occurred.

Cost - The capital and O&M costs for vapor-phase carbon are moderate.

Screening - Because air stripping and vacuum extraction have been retained, vapor-phase carbon has also been retained to handle off-gases from these processes.

In-Situ Air Sparging

Description - During in-situ air sparging, compressed air is forced into the saturated soil through an injection well that has a screen located beneath the water table. The injected air moves outward and upward from the injection point, temporarily displacing water from the soil pores. Lateral movement of air tends to be significant because horizontal permeability is typically higher than vertical permeability. As the air moves through the saturated zone, VOCs present in the water or soil partition into the vapor phase. The VOCs travel upward with air to the unsaturated zone where they are captured by vapor extraction wells.

Effectiveness - In order for an air sparging/vapor extraction system to be effective: (1) the water table aquifer must have a hydraulic conductivity of 10^{-3} cm/sec or more to ensure that injected air can displace water in the pore spaces and create pathways to the unsaturated zone, and (2) the VOCs must be relatively insoluble (<5000 mg/l). Highly soluble VOCs will not partition to the air and therefore will not be effectively removed. The hydraulic conductivity of the overburden ranges from 1.8×10^{-4} to 1.2×10^{-1} cm/sec, which is typical of fine to coarse sand. The solubilities of the compounds and products of concern range from 0.122 mg/l for nonane (major component of Stoddard solvent) to 1750 mg/l for benzene. Based on the low solubilities and the range of hydraulic conductivities, it is expected that air sparging would improve the effectiveness of soil vapor extraction. In the Eastern Parking Lot, however, where a substantial amount of free product has been detected, the product could be released by the flow of air and move down gradient, causing higher VOC concentrations to be detected in down gradient wells. The same problem exists to a smaller extent in the Tank K Area. Also, the background levels of iron (0.68 - 450 mg/l) and manganese (0.07-6.5 mg/l) in the groundwater are fairly high. Oxidizing the subsurface could result in significant precipitation of iron and manganese oxides and hydroxides which could clog soil pore spaces and the delivery system. This clogging of pore spaces could cause a significant impact on the extraction of groundwater or soil gas.

Implementability - The equipment (wells and blowers) for an air sparging system are readily available. The system would be employed in conjunction with a soil vapor extraction system and contaminated air treatment system.

Cost - The capital and O&M costs for air sparging are expected to be low to moderate.

Screening Due to the concern for free product mobility, and iron and manganese precipitation, air sparging will be eliminated from further consideration.

3.2.2.5 Disposal

Injection Wells

Description - Groundwater injection wells serve several purposes; 1) to dispose of treated groundwater, 2) to direct contaminants to the extraction wells or trenches, and 3) to create a groundwater barrier to change both the direction of a plume and the speed of plume migration.

Effectiveness - Groundwater injection wells could be used at the site both to create hydraulic barriers and to increase the flow of contaminants toward collection wells or trenches. Groundwater injection is an effective means of disposing of treated groundwater as long as groundwater discharge limits are being met. The complex hydrogeology of the site, however, brings effectiveness into question.

Implementability - Injection wells are easily implemented and the equipment is readily available. A discharge permit would be required from the MA DEP under 314 CMR 5.00 "Groundwater Discharge Permit Program." Monthly sampling of the reinjected effluent would be required.

Cost - The capital and O&M costs for groundwater reinjection would be moderate.

Screening - Groundwater reinjection will be eliminated from further evaluation for the following reasons: 1) there is more mounding than with surface water discharge,

2) there is more effect on water elevation in the wetlands than with a surface water discharge, and 3) there is more permitting required than with a surface water discharge.

Surface Water Discharge

Description - Under this option, treated effluent from the groundwater treatment plant would be discharged to the wetlands east of the property.

Effectiveness - As long as the groundwater treatment plant was meeting the limits for surface water discharge, this would be an effective means of disposing of treated groundwater. A properly designed diffuser will reduce potential effects of mounding in the wetlands. By returning treated water to the wetland, the effects of pumping on the wetlands can be reduced.

Implementability - A NPDES Permit will be required for surface water discharge. Monthly sampling of the effluent will be required.

Cost - The capital cost for surface water discharge is relatively low. The O&M costs would be low to moderate depending upon sampling requirements.

Screening - Discharge to surface water discharge will be retained for further evaluation.

3.2.3 Summary of Retained Technologies

Tables 3-4 and 3-5 summarize the findings of detailed screening of remediation technologies for soil/sediment and groundwater, respectively. The tables indicate the main points concerning the effectiveness and implementability of the technologies and process options. The criteria of cost was not used in the screening, with the exception of soil washing, and is not summarized.

A review of this detailed screening for soils/sediment results in the following conclusions:

1. No Action retained as a baseline.
2. Deed restrictions are retained for combination with other remedial actions.
3. Containment by subsurface barrier is retained solely for soil stabilization during excavation. The only technology retained is sheet pile walls due to their effectiveness for this type of application.

Table 3-4

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
No Action	None	Not Applicable	• Does not achieve remedial objectives	• Readily implementable • Not acceptable to regulatory agencies	• Retained for baseline comparison of alternatives
Institutional Actions	Access Restrictions	Deed Restrictions	• Effectiveness depends on continued future implementation • Does not reduce contamination	• Cooperation among various governmental agencies and property owners may be required • Legal requirements	• Retained for combination with other remedial technologies
Containment	Vertical Barriers	Sheet Pile Wall	• Applicable for reducing mobility of separate phase product • Effective for stabilizing areas requiring excavation • Does not reduce contamination • Does not achieve all remedial objectives	• Readily implementable for depth required (less than 15 feet)	• Retained for combination with other remedial technologies
Removal	Excavation	Soil Excavation/ Mechanical Dredging	• Very effective in reducing contamination in original source area • Must be combined with treatment and disposal technologies to meet remedial objectives	• Large volumes and areas of contamination must be staged due to potential disruptions to existing operations	• Retained

Table 3-4
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Treatment (In-Situ)	Physical/Chemical	Soil Vapor Extraction	• Effective for removal of contaminants in the vadose zone • Capable of meeting remedial objectives for unsaturated soils	• Readily implementable • Off-gas treatment potentially required	• Retained
Treatment (Ex-Situ)	Thermal	Off-Site Incineration	• Effective destruction of organics in separate phase product and/or soil • Meets remedial objectives for excavated soils	• Permitted TSD facilities that accept the contaminated soil are not available in local area	• Eliminated
		Low Temperature Thermal Desorption	• Effective in removing petroleum and solvent related contaminants from soil • Meets remedial objectives for excavated soils	• On- and off-site services are available but limited • Readily handle all concentrations found on-site	• Retained as a potential cost effective alternative to off-site incineration
		Soil Washing	• Questionable effectiveness due to the separate phase product and silty nature of soils • Treatability testing required	• Limited field experience • Limited availability of equipment • Aqueous solution treatment required	• Eliminated
		Thickening/ Dewatering	• Effective for reduction of weight of saturated soils • Does not meet remedial objectives	• Readily implementable • Wastewater generated requires further treatment	• Retained for use with all excavated saturated soils

Table 3-4
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WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
SOIL/SEDIMENT

Soil General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Treatment (Ex-Situ)	Physical/Chemical	Asphalt Batching	• Does not reduce the volume of contamination but does significantly reduce mobility	• Off-site and on-site services are readily available • Some soils may exceed acceptance levels	• Retained
	Biological	Aerobic	• Effective in treating gasoline • Effectiveness in treating Stoddard solvent is questionable	• Requires semi-permanent storage area and results in extended site use disruption	• Eliminated
Disposal	Off-Site	TSD Facility	• No reduction in contaminant toxicity or volume • Migration of contaminants better controlled in a secure landfill	• Readily implementable • Liability issues	• Retained, however, should be minimized
	On-Site	Reuse	• Effective use of treated soils if paving is required (asphalt batching) or backfilling is required (low temperature thermal desorption) • Minimizes the amount of clean fill required	• Soil must be treated to meet Land Disposal Restrictions • Cold mix asphalt emulsion can only be placed above water table	• Retained

Table 3-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
No Action	None	Not Applicable	• Does not achieve remedial objectives	• Readily implementable • Not acceptable to regulatory agencies	• Retained for baseline comparison of alternatives
Containment	Vertical Barriers	Sheet Pile Wall	• Effective in reducing clean water collection in an excavation • Does not achieve all remedial action objectives	• Readily implementable for depths required (less than 15 feet)	• Retained for combination with collection technologies
Collection	Extraction	Extraction Wells	• Effective for the removal of contaminated groundwater from shallow and deep overburden and bedrock aquifers • When employed with groundwater treatment options, groundwater cleanup levels will be met	• Readily implementable • Treatment and/or disposal of recovered groundwater required	• Retained

Table 3-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Collection	Subsurface Drains	Interceptor Trenches	• Effective for removal from shallow overburden, particularly in strata with low hydraulic conductivity • When employed with groundwater treatment options, groundwater cleanup levels will be met • Effective removal of separate phase product	• Readily implementable • Treatment and/or disposal of recovered groundwater/ product required	• Retained
Treatment (Ex-Situ)	Physical/Chemical	Air Stripping	• Effective method for removal of contaminants of concern	• Readily implementable • Pretreatment required • Off-gas treatment potentially required	• Retained

Table 3-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Treatment (Ex-Situ)	Physical/Chemical	Carbon Adsorption	• Effective removal of high-molecular weight, non-polar compounds • May not be a cost effective option for removal of low-molecular weight, polar compounds (i.e., halogenated hydrocarbons)	• Readily implementable • Carbon must be disposed or regenerated • Pretreatment required	• Retained
		Chemical Oxidation	• Relatively effective for destroying aromatic hydrocarbons and halogenated olefins • Alkanes and halogenated alkanes require greater detention times	• Readily implementable • Pretreatment required	• Retained
		Chemical Precipitation	• Effective removal of iron, manganese and phosphorus (if lime is used) to meet discharge criteria	• Readily implementable • Sludge handling required	• Retained

Table 3-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Treatment (Ex-Situ)	Physical/Chemical	Filtration (Filter Press)	• Filter press effective for dewatering hydroxide sludges	• Readily implementable • Filtrate requires treatment • Sludge must be disposed	• Retained
		Filtration (Gravity Filter)	• Granular media filtration effective for suspended solids removal to < 10 mg/l	• Readily implementable • Backwash water treatment required	• Retained
		Gravity Separation	• Effective removal of oil and grease prior to dissolved organic treatment	• Readily implementable • Recovered product requires proper disposal	• Retained
		Reverse Osmosis	• Effective removal of dissolved solids, particularly high molecular weight organics and charged anions and cations	• Readily implementable • Pretreatment required • Treatment of brine solution (reject) is required	• Eliminated, total dissolved solids not anticipated to be a problem
		Neutralization	• Effective pH adjustment of groundwater with high pH resulting from chemical precipitation process	• Readily implementable	• Retained

Table 3-5
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Treatment (Ex-Situ)	Physical/Chemical	Vapor Phase Carbon	• Depending on the contaminant, vapor-phase adsorption capacity can be 3 to 20 times higher than for liquid-phase capacity	• Readily implementable • Monitoring required to determine breakthrough • Relative humidity of vapor stream must be less than 50% • Carbon requires disposal or regeneration	• Retained
	Thermal	Catalytic Oxidation	• Effective removal of contaminants in the emissions from soil vapor extraction or air stripping	• Readily implementable • High concentrations of chloro-organics may result in need for caustic scrubber	• Retained

Table 3-5
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Treatment (In-Situ)	Physical/Chemical	Air Sparging	• Based on range of contaminant solubilities and hydraulic conductivities, air sparging is expected to improve the effectiveness of soil vapor extraction and groundwater treatment	• Readily implementable • Must be employed in conjunction with a soil vapor extraction system and contaminated air treatment system • Effectiveness may be impaired by very high levels of iron in groundwater	• Eliminated due to potential for clogging of pore spaces

Table 3-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
DETAILED SCREENING OF GENERAL RESPONSE ACTIONS AND TECHNOLOGY PROCESS OPTIONS
GROUNDWATER

Groundwater General Response Action	Remedial Technology	Process Option	Effectiveness	Implementability	Screening Result
Disposal	On-Site Discharge	Injection Wells	• In general, an effective means for creating hydraulic barriers and increasing flow toward collection systems • Complex hydrogeology of site brings effectiveness into question	• Readily implementable • Discharge permit required	• Eliminated due to uncertainties concerning the effects of reinjected groundwater on contaminant transport. Also this form of discharge will not reduce effects of pumping on the wetlands
Disposal	On-Site Discharge	Surface Water	• An effective means of treated groundwater disposal • Aid in reducing effects of pumping on wetlands and groundwater depression in Eastern Parking Lot	• Readily implementable • Discharge permit required	• Retained

4. Removal of soil is retained for areas where in-situ treatment is either technological infeasible or cost prohibitive. Large areas of excavation are to be staged to minimize disruption to existing operations.
5. Soil vapor extraction is the only in-situ treatment technology deemed effective and implementable.
6. Ex-situ treatment methods were reduced to low temperature thermal desorption and asphalt batching.
7. Off-site disposal of untreated soil was retained but is to be minimized. For the most part, treated soils are to be used on-site either as backfill or paving material.

A review of this detailed screening for groundwater results in the following conclusions:

1. No Action is retained as a baseline.
2. Containment by subsurface barrier is retained solely for reducing groundwater collection in an excavation or interceptor trench. As with soils, the only technology retained is sheet pile walls.
3. Groundwater can be effectively collected by extraction wells and interceptor trenches. Interceptor trenches were also retained for recovery of product.
4. The only ex-situ groundwater treatment method eliminated was reverse osmosis, in that total dissolved solids were not deemed to be a problem. The technologies retained for VOC removal are air stripping, carbon adsorption and chemical oxidation. Pretreatment technologies retained are gravity separation, chemical precipitation, neutralization and filtration. Ancillary technologies retained for off-gas treatment are vapor phase carbon and catalytic oxidation.
5. The only in-situ groundwater treatment retained from the initial screening, air sparging, was eliminated. The major concern was clogging of pore spaces due to high iron and manganese concentrations.
6. Disposal of treated groundwater was reduced to surface water discharge because of less permitting requirements and less significant effects on the wetlands.

In Chapter 4.0, the retained remedial technologies discussed above will be assembled into the soil and groundwater collection/treatment components of the remedial action alternatives.

4.0 DEVELOPMENT AND SELECTION OF SOIL AND GROUNDWATER COMPONENTS OF REMEDIAL ACTION ALTERNATIVES

4.1 OVERVIEW OF DEVELOPMENT/SELECTION OF COMPONENTS

In this section, the technologies and process options that were retained in Section 3.3 are combined to develop soil treatment components, groundwater collection components, and groundwater treatment components. These components will subsequently be combined in Section 5.0 to form remedial action alternatives to address the entire site as a whole. Due to the complexity of the site with respect to the multiple locations, media, and types of contaminants to be addressed, Wehran believes that the development and evaluation of some of these components in Section 4.0 will serve to simplify and clarify the selection of remedial action alternatives in Section 5.0. As an example, the risk assessment indicated that soil/sediment only needs to be addressed on-property and at the outfall basins. As a result, the selection of a soil treatment component can be made in Section 4.0 independent of the evaluation of groundwater collection/treatment components given that the quantities of soil and soil cleanup objectives will remain constant in the evaluation of remedial action alternatives.

4.2 CHARACTERIZATION OF SOIL/SEDIMENT

4.2.1 Estimated Volume of Soil Contamination

As described in Section 2.0, based on the results of the ADL risk assessment, soil remediation is required in the following areas of the property: Eastern Parking Lot, Tank Farm/Drum Storage Area, and Tank K. For the purposes of this feasibility study, Wehran estimated the extent of soil contamination requiring remediation in each of these areas based upon two criteria: 1) soil contamination measured by laboratory results which exceeded the cleanup levels set forth in Section 2.3.2, and 2) concentrations of total VOCs measured in soil gas by field GC which exceed estimated risks as determined by the ADL Risk Assessment. Because the soil data available in each of the areas identified for remediation is limited, the estimated extent of soil contamination was based largely on soil gas information.

In order to delineate the approximate extent of soil to be remediated using soil gas data, Wehran used the average soil gas total VOC concentrations in each area and the sub-chronic hazard index calculated by ADL. Using this information, Wehran calculated an acceptable total VOC concentration for each area (using an acceptable sub-chronic hazard index of one [1]). The total VOC soil gas concentrations used to delineate the extent of soil contamination in each area are as follows:

Eastern Parking Lot	20 ppm
Tank Farm and Drum Storage Areas	10 ppm
Tank K Area	0.1 ppm

The acceptable total soil gas concentrations are different because the types and concentrations of contaminants are different in each area.

The use of these soil gas concentrations is expected to overestimate the soil volume to be remediated, primarily because: 1) it assumes that the soil gas concentrations correlate with, and are attributable solely to soil concentrations (unlikely to be the case given the shallow depth to groundwater) and 2) the soil gas data is approximately 5 years old and concentrations are likely to have decreased. Prior to remedial design, additional samples will be collected from the unsaturated zone for laboratory analysis to confirm the extent of soil to be remediated.

The areal extent of soil to be remediated as delineated by the soil gas criteria is indicated on Figure 4-1. The vertical extent was determined using site cross sections and laboratory analytical data. In addition, the vertical thickness of the unsaturated zone requiring remediation will be increased as a result of drawdown caused by groundwater extraction in each area.

To simplify calculations, the Eastern Parking Lot Area is divided into two zones: 1) paved zone (depth to bedrock of 7' - 45') and 2) unpaved zone (depth to bedrock of 2.5' - 7', average 3'). The areal extent of contamination in the paved and unpaved zones as determined by the soil gas survey is 25,000 and 11,000 square feet, respectively. These areas are indicated on Figure 4-1. The major problem in the paved area is the presence of separate phase product (Stoddard solvent).

In order to prevent smearing, the separate phase product would need to be removed before a groundwater recovery system was operated. Therefore, the depth of excavation

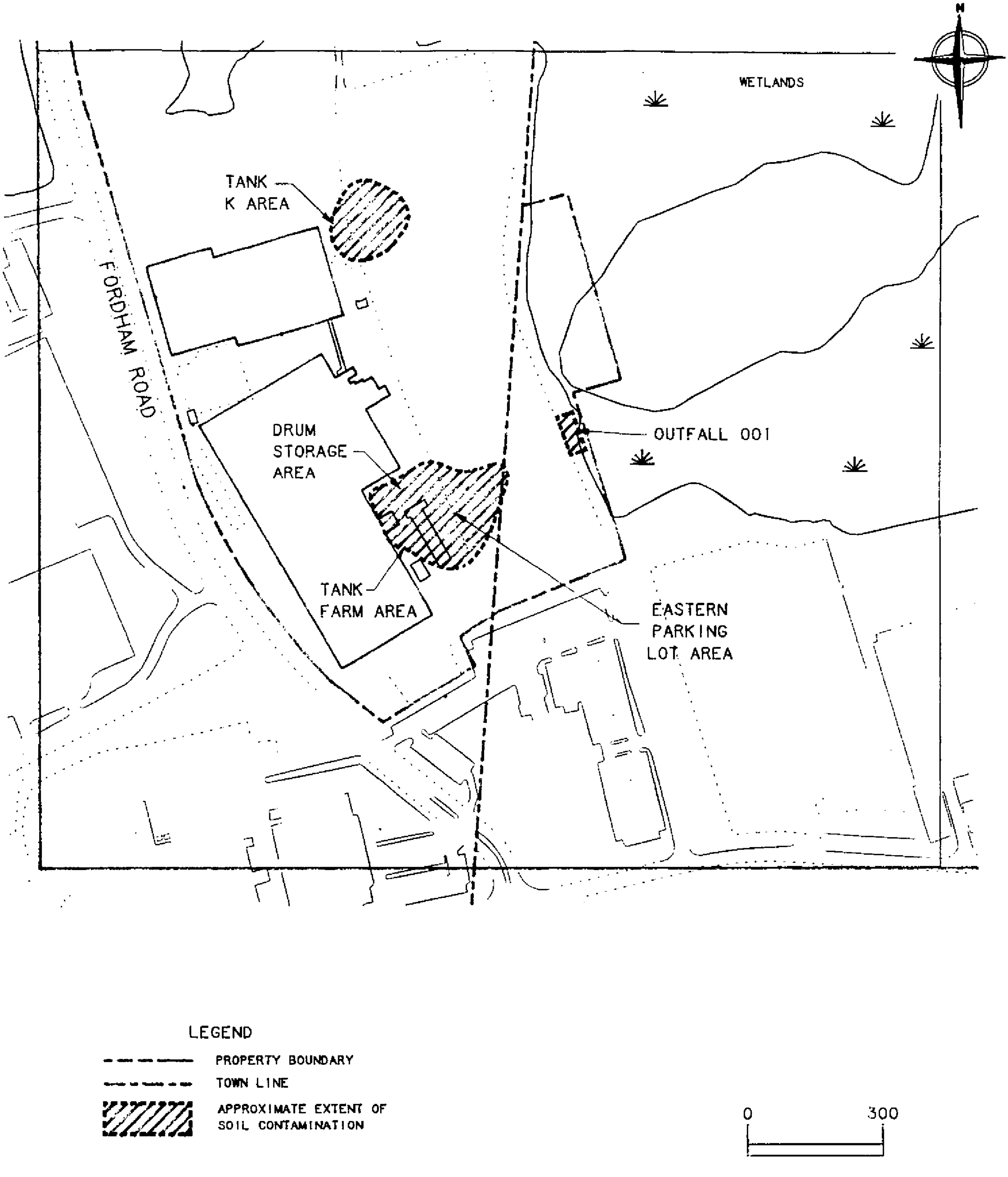

FIGURE 4-1

APPROXIMATE EXTENT OF SOIL CONTAMINATION

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

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Wehran Engineering Corporation

WEHRAN PROJECT NO. 01501.0

would be to the existing water table (5' - 6') or bedrock in the cases occurs below the bedrock surface. The total volume of contaminated soil for the two zones is estimated at 1300 CY (unpaved), and 5700 CY (paved). This is summarized in Table 4-1.

The Tank Farm and Drum Storage Areas are also addressed separately: 1) Drum Storage Area (depth to bedrock 2.5' - 3') and 2) Tank Farm Area (depth to bedrock 6' - 10'). The areal extent of the contamination in the Drum Storage and Tank Farm Areas as determined by soil gas concentrations is estimated at 8,000 and 5,400 square feet, respectively. For the purposes of estimating soil volumes, it is assumed that all soil in the Drum Storage Area (to a 3' depth to bedrock) requires remediation, and the pumping in the Tank Farm Area (caused by the operation of groundwater extraction system) will dewater all soils (to a 10' depth to bedrock). The laboratory data from B-16 in the existing saturated zone (8' - 10') indicates the need for remediation for TPH (either by excavation or in-situ treatment). Using these assumptions, the approximate volumes of soil are calculated as 900 CY for the Drum Storage Area and 2000 CY for the Tank Farm Area.

In the Tank K area, the existing water table is 4' - 5' below the ground surface. The groundwater recovery system for this area is predicted to cause an additional 3.5 - 6.5 feet of drawdown. This results in the groundwater table being lowered to 8 - 11 feet below ground surface when the groundwater recovery system is operating. The laboratory data from WE-4D in the existing saturated zone (6' - 8') indicates the need for remediation for TPH and BTEX compounds (either by excavation or in-situ treatment). Therefore, the depth of unsaturated soils requiring remediation in the Tank K Area is approximately 10 feet. The areal extent of contamination is approximately 22,500 square feet. This represents a total volume of 8300 cubic yards.

4.2.2 Estimated Volume of Sediment Contamination

Sediment samples were collected during the Phase II investigations from Outfall Basins 001 and 002, and the Drainage Ditch. The cleanup objective for TPH (5000 mg/kg) was only exceeded in several samples collected from Outfall Basin 001. These samples were all collected in close proximity to the outfall and based on their distribution, the areal extent of elevated TPH is estimated at 3600 square feet (Figure 4-1). For the purpose of estimating the sediment volume to be remediated, a depth of 3 feet was assumed, yielding a total volume of approximately 400 CY.

Table 4-1

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
ESTIMATED VOLUME OF SOIL TO BE REMEDIATED

Soil Contamination Area	Areal Extent (ft^2)	Depth (ft)	Estimated Volume (CY)
Eastern Parking Lot			
Paved	25,000	6	5700
Unpaved	11,000	3	1300
Tank Farm	5400	10	2000
Drum Storage	8000	3	900
Tank K	22,500	10	8300

4.2.3 Estimated Volume of Separate Phase Product

In general, the extent of separate phase product in the Eastern Parking Lot is the same as that for the soil contamination (see Figure 4-1). Monitoring that has been performed as part of the Eastern Parking Lot Interim Measure indicates product thicknesses from 0 - 0.95 ft. For the purposes of this feasibility study, an average product thickness is assumed of 0.25 ft. The following data was used to determine the average volume of separate phase product:

Area	= 25,000 ft^2
Thickness	= 0.25 ft (average over area)
Soil Porosity	= 0.3

The resultant volume is approximately 14,000 gallons of Stoddard solvent in the Eastern Parking Lot.

4.3 DEVELOPMENT OF SOIL/SEDIMENT COMPONENTS

4.3.1 Remedial Soil Options

The technologies and process options which were retained for soil/sediment remediation in Section 3.3 were: vertical barriers (sheet piling), excavation, soil vapor extraction, low temperature thermal desorption, dewatering, asphalt batching, off-site disposal and on-site reuse. These technology process options are assembled into remedial soil options in Section 4.3.1.1 through 4.3.1.4 to address each area of soil/sediment contamination. In Section 4.3.2, these remedial soil options are formulated into soil components which address the entire site.

4.3.1.1 Eastern Parking Lot

In the Eastern Parking Lot unsaturated soils should be remediated and separate phase product (Stoddard solvent) should be removed. The use of vertical barriers to contain the separate phase product is not an acceptable option because it would not achieve the cleanup objectives (i.e., removal of separate phase product and TPH levels in the soil to less than 5000 mg/kg). The soil can be treated in-situ (soil vapor extraction, product recovery trenches), excavated and treated ex-situ (low temperature thermal desorption, asphalt batching), or excavated and disposed off-site.

The unpaved area between Building 3 and the parking lot has a depth to bedrock of only 2 to 3 feet. This shallow depth prevents the effective use of either soil vapor extraction or product recovery trenches, leaving excavation as the only viable option. The quantity of soil to be excavated from this area is approximately 1300 CY. This quantity of soil can be treated economically either on- or off-site. The disposal of contaminated soil off-site (i.e., landfill) should be minimized based on liability issues (Section 3.2.1.6). Therefore, for the quantities of soil which would be excavated from the Eastern Parking Lot, off-site disposal would not be appropriate. As a result, off-site land disposal will be eliminated from further consideration. The two remaining options for remediating the Eastern Parking Lot soils are:

1) Excavate both paved and unpaved zones
2) Excavate unpaved zone, treat paved zone with a combination of product recovery trenches and soil vapor extraction wells

The excavated soils under either option can be treated several ways: on- or off-site thermal desorption or on- or off-site asphalt batching.

Under the first option, soil excavation and product removal would be accomplished prior to the operation of the groundwater recovery system to avoid the smearing of separate phase product. The excavation performed under this option would be accomplished using steel sheet piling. The sheet piling serves four purposes: 1) allows excavation to be performed in stages, reducing the disruption to the existing parking lot, 2) prevents sloughing of clean soils into the excavation, 3) reduces the amount of dewatering which must be performed to recover separate phase product, and 4) reduces probability of recontaminating clean soils.

Under the second option, separate phase product would be collected through the use of 4 foot wide trenches, 20 foot on center and 1 foot drain depth (i.e., a groundwater elevation drawdown of an additional foot beyond that caused by the pumping system). The proposed on-property groundwater collection system results in an estimated 1 - 2 foot drawdown of the groundwater table over the Eastern Parking Lot. The estimated flow rate into the trench system is 0.75 gpm. Using a retardation factor (R) for Stoddard solvent of 940, the trench system will collect approximately 1.5 gpd of product. The retardation factor (a function of a compound's sorption partition coefficient, K_{oc}) is a measure of a compound's movement relative to the bulk mass of groundwater. Contaminants that sorb to soil material (e.g., Stoddard solvent) move slower through an aquifer than those that do not sorb.

It should be noted that drawdown in the trenches may cause significant smearing of separate phase product across soils below the existing product layer. To approach the cleanup objective of 5000 mg/kg TPH in these soils, a soil vapor extraction system would be required to address residual product adsorbed to the soil. The soil vapor extraction system would be constructed with a horizontal extraction well which would be placed in each of the trenches. The design criteria used for the preliminary sizing of the vapor extraction systems is presented in Table 4-2. The air permeability, well pressure, and well radius and influence are used to determine achievable vapor flow rates per unit length of well and also the efficiency of transferring contaminants from the soil to the soil gas. This data is used to preliminarily determine the number of wells required, total flow rate, time for cleanup and contaminant concentration in vapor. The vapor concentration dictates the type of off-gas treatment. Preliminary design indicates 1300 - 1400 feet of 4 inch horizontal wells and a total air flow rate of 2000 cfm would be required to treat the soils. The estimated vapor concentration extracted by the system is less than 5 ppm-v.

The Soil Vapor Extraction Technology Reference Handbook (EPA/540/2-91/003) indicates that GAC vapor treatment technology is effective for vapor concentrations in the range of 0.1 - 300 ppm-v, and catalytic oxidation for vapor concentrations in the range of 300 - 15,000 ppm-v. Based on this information, a GAC vapor phase carbon system would be used to treat the air stream.

The combined action of the soil vapor extraction system and the product collection trenches would require an estimated 15 years to remove the residual product below the 5000 mg/kg cleanup level. The reason for such a long operating period is three fold: 1) high retardation factor of Stoddard solvent which results in slow recovery, 2) the soils in the Eastern Parking Lot have a low soil permeability to air flow ($k = 3.0 \times 10^{-7} cm^2$ vs. $4.0 \times 10^{-6} cm^2$ for Tank K soils) and 3) low volatility of Stoddard solvent. The estimated vapor pressure for fresh and weathered gasoline is 190 mmHg and 25 mmHg, respectively at 10°C. The vapor pressure for Stoddard solvent is 1.8 mmHg, significantly less volatile. These combined factors make product collection trenches and soil vapor extraction in the Eastern Parking Lot difficult to implement effectively.

Table 4-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PRELIMINARY DESIGN CRITERIA - SOIL VAPOR EXTRACTION

Parameter	Area		
	Eastern Parking Lot	Tank Farm	Tank K
1. Air Permeability (cm^2)*	2.8×10^{-6}	3.8×10^{-6}	3.8×10^{-6}
2. Well Pressure (atm)	0.95	0.95	0.95
3. Well Configuration	Horizontal	Vertical	Vertical
4. Well Radius (in)	4	4	4
5. Radius of Influence (ft)	10	40	40
6. Vapor Concentration (ppm-v)	10	15	360
7. Vapor Phase Carbon Usage (lb/d)	100	45	230
8. Total Air Flow (cfm)	2000	750	500

Notes:

* Estimated from hydraulic conductivity.

Once the soils are stockpiled (under either option) samples will be collected and submitted to a laboratory for chemical characterization (TPH, VOCs, metals). Based on discussions with vendors, approximately 30 composite samples would be needed for 7000 CY and 10 composite samples for 1300 CY.

If the soils are treated by on-site thermal desorption, the treated soils would be returned to the excavation. For evaluating the effects to existing operations, the estimated area requirement for the equipment is 5,000 - 7,500 square feet. If the soils are treated by on-site asphalt batching, the excavation would be backfilled with clean fill. The asphalt emulsion recycled soil can be used as a base course for a bituminous concrete wearing course in repaving the parking lot. The estimated area for the equipment is 12,000 - 18,000 square feet. If the soils are treated by off-site thermal desorption or asphalt batching, the excavation would be backfilled with clean fill material.

4.3.1.2 Tank Farm/Drum Storage Area

Unsaturated soils in the Tank Farm and Drum Storage Areas must be remediated, as well as the saturated soils which will be dewatered by a groundwater extraction system in the Tank Farm Area. As with the Eastern Parking Lot, the soil can be treated in-situ (vapor extraction), or excavated and treated ex-situ (thermal desorption or asphalt batching).

The area designated as the Drum Storage Area has a depth to bedrock of only 3 feet. Soil vapor extraction would not be effective. The two general viable options for the Farm/Drum Storage Area are:

1) Excavate Drum Storage Area and Tank Farm Area.
2) Excavate Drum Storage Area; treat Tank Farm Area with soil vapor extraction.

with the underlying

The excavated soils under either of these options can be treated by several meth on- or off-site thermal desorption or on- or off-site asphalt batching.

Under the first option, soil excavation in the Tank Farm Area would occur in an area with significant underground piping and utilities. For costing purposes, it is estimated that 75% of the excavation would be accomplished by hand. As with the Eastern Parking Lot, soil samples would be taken from the perimeter of the excavation to assure that all soil which exceed cleanup levels has been removed. Also, stockpiled soils would be sampled for TPH, VOCs and metals (approximately 15 sample composites).

Under the second option, soil vapor extraction would replace excavation in the Tank Farm Area. The preliminary design criteria for the soil vapor extraction system for the Tank Farm Area are summarized in Table 4-2. The soil vapor extraction system proposed for this option includes three-4 inch vertical extraction wells with a total flow of 750 scfm. The estimated vapor concentration extracted by the system is 15 ppm-v. Based on criteria presented earlier, the most cost effective vapor treatment technology is activated carbon. Due to the low volatility of Stoddard solvent, it is estimated that the extraction system would be required to operate for approximately 8 years to remove separate phase Stoddard solvent and achieve cleanup objectives.

removing separate phase? NO!

4.3.1.3 Tank K Area

The unsaturated soils and saturated soils which would be dewatered by a groundwater extraction system in the Tank K Area should be remediated. As with the other areas, the two general options for the Tank K Area are:

1) Excavate and treat by thermal desorption or asphalt batching.
2) In-situ treatment with soil vapor extraction

As in the Eastern Parking Lot, excavation would be accomplished using sheet piling to allow staging, prevent sloughing of clean soils and minimize dewatering. Soil samples would be taken at the perimeter of the excavation to assure that all contaminated soil is excavated. Soil would be stockpiled and sampled (35 composites) for TPH, VOCs and metals.

The preliminary design criteria for the SVE system in the Tank K Area are summarized in Table 4-2. A soil vapor extraction system would include five-4 inch vertical extraction wells and a total flow of 500 scfm. The estimated vapor concentration extracted by the system is 360 ppm-v initially. Because of these higher vapor concentrations, the most appropriate treatment for the Tank K soil vapor extraction system is catalytic oxidation. Although the vapor concentrations will decrease with time, catalytic oxidation was determined to be more cost effective than carbon adsorption for the Tank K Area. The extraction system would need to be operated for approximately 3 years. The shorter operating time for the SVE system in the Tank K Area (compared to the Eastern Parking Lot or Tank Farm) is attributed to: 1) significantly higher vapor pressure of weathered gasoline compared to that of Stoddard solvent, and 2) a tenfold increase in the air permeability of soils in Tank K compared to those in the Eastern Parking Lot.

4.3.1.4 Outfall 001 Sediments

No in-situ technology was identified for treating the contaminated sediments. The quantity of sediments (400 CY) might make off-site disposal feasible if it was the only excavated material. However, the cumulative quantity of soil which should be excavated from other areas (unpaved portion of Eastern Parking Lot - 1300 CY, Drum Storage Area - 900 CY) rules out off-site disposal from a liability and economic standpoint. Therefore, the only option for the sediments is excavation and ex-situ treatment.

The area for excavation would be isolated by steel sheet piling and excavated using a clamshell. The piling would minimize the quantity of clean sediment which might slough into the excavation and would limit disruption of adjacent wetland areas. As with the other options, sediment would be stockpiled and sampled for TPH, VOCs and metals.

4.3.2 Formulation of Soil Components

The soil remedial options for particular areas of contamination developed in Section 4.3.1 are formulated into the following five soil components, which address the entire site. For each of these components, excavated soil would be treated ex-situ using thermal desorption or asphalt batching, either on- or off-site.

The first soil component (S-1) would involve the excavation of all contaminated soil and sediment (approximately 18,500 CY or 25,000 tons).

The second soil component would involve soil vapor extraction in the Tank Farm Area with excavation of remaining areas (Eastern Parking Lot, Tank K, Drum Storage and Outfall 001). The main purpose for this component is to provide an option to excavating the Tank Farm Area, which is a high use area and the location of many underground utilities. The total quantity of excavated soil in this component is approximately 16,500 CY (22,000 tons).

The third soil component (S-3) would involve soil vapor extraction at Tank K and excavation in all other areas. This component takes into consideration that soil vapor extraction is more effective in some area than others. In the description of remedial options, it was noted that the SVE system in the Tank K area would operate for 3 years. However, if the SVE systems were installed for the Eastern Parking Lot and Tank Farm, they would need to operate for 15 and 8 years, respectively. The total quantity of excavated soil in this component is approximately 10,000 CY (13,500 tons).

The fourth soil component (S-4) would involve soil vapor extraction at the Tank Farm and Tank K Areas. This component integrates the advantages of components S-2 and S-3, namely, avoidance of excavation in a high use area (Tank Farm) and use of SVE where it is most effective (Tank K). The total quantity of soils in this component which would be excavated and treated ex-situ is approximately 8,500 CY or 11,000 tons.

The final soil component (S-5) would involve soil vapor extraction system in the Tank Farm and Tank K Areas, and a combination soil vapor extraction/product recovery in the Eastern Parking Lot. In addition, the unpaved portion of the Eastern Parking Lot, the Drum Storage Area and Outfall 001 would be excavated. The total quantity of excavated soil in this component is approximately 2,500 CY (3,500 tons).

4.4 EVALUATION AND SELECTION OF SOIL COMPONENT

As was indicated in Section 4.1, in an effort to simplify and clarify the development of remedial action alternatives, the evaluation and selection of soil components will be performed independent of the groundwater collection/treatment components. In this section, a two part evaluation of the five soil components will be presented. The first part is an evaluation of issues involved with in-situ treatment, versus excavation with ex-situ treatment. From this evaluation, one soil component will be selected. The purpose of the second part of the soil component evaluation is to select a treatment option for the excavated soils. In both steps of the evaluation, the criteria which are used are the same as those identified in 310 CMR 40.0858 for the evaluation of remedial action alternatives i.e., effectiveness, reliability, implementability, cost, risk, benefit, timeliness and non-pecuniary. The criteria are defined below as they appear in 310 CMR 40.0858:

1. The comparative effectiveness of the alternatives in terms of:
   a. achieving a Permanent or Temporary Solution under 310 CMR 40.1000;

b. reusing, recycling, destroying, detoxifying, or treating oil and hazardous material at the disposal site; and

c. reducing levels of untreated oil and hazardous material at the site to concentrations that achieve or approach background.

2. The comparative short-term and long-term reliability of the alternatives, including:

a. the degree of certainty that the alternative will be successful; and

b. the effectiveness of any measures required to manage residues or remaining wastes or control emissions or discharges to the environment.

3. The comparative difficulty in implementing each alternative in terms of:

a. technical complexity of the alternative;

b. where applicable, the integration of the alternative with existing facility operations and other current or potential remedial actions;

c. any necessary monitoring, operations, maintenance or site access requirements or limitations;

d. the availability of necessary services, materials, equipment, or specialists;

e. the availability, capacity and location of necessary off-site treatment, storage and disposal facilities; and

f. whether the alternative meets regulatory requirements for any likely approvals, permits or licenses required by the Department, or other state, federal or local agencies.

4. The comparative costs of the alternatives, including:

a. costs of implementing the alternative, including without limitation: design, construction, equipment, site preparation, labor, permits, disposal, operation, maintenance and monitoring costs;

b. costs of environmental restoration, potential damages to natural resources, including consideration of impacts to surface waters, wetlands, wildlife, fish and shellfish habitat; and

c. the relative consumption of energy resources in the operation of the alternatives, and externalities associated with the use of those resources.

5. The comparative risks of the alternatives including without limitation:
   a. the short-term on-site and off-site risks posed during implementation of the alternative associated with any excavation, transport, disposal, containment, construction, operation or maintenance activities, or discharges to the environment from remedial systems;
   b. on-site and off-site risks posed over the period of time required for the alternative to attain applicable remedial standards, including risks associated with ongoing transport, disposal, containment, operation or maintenance activities, or discharges from remedial systems; and
   c. the potential risk of harm to health, safety, public welfare or the environment posed to human or environmental receptors by any oil and/or hazardous material remaining at the disposal site after the completion of the remedial action.

6. The comparative benefits of the alternatives including without limitation:
   a. the benefit of restoring natural resources;
   b. providing for the productive reuse of the site;
   c. the avoided costs of relocating people, businesses, or providing alternative water supplies; and
   d. the avoided lost value of the site.

7. The comparative timeliness of the alternatives in terms of eliminating any uncontrolled sources of oil and/or hazardous material and achieving of a level of No Significant Risk as described in 310 CMR 49.0900.

8. The relative effect of the alternatives upon non-pecuniary interests, such as aesthetic values.

The results of the two part evaluation are presented in Tables 4-3 and 4-5, respectively. For each criteria, the components are assigned a qualitative rating from good (G) to poor (P). For the two parts of the evaluation, these ratings are summarized in Table 4-4 and 4-6. The discussion below summarizes the critical differences between the components under each evaluation criteria, and basis for the selection of one component.

4.4.1 In-Situ/Ex-Situ Treatment Evaluation

In evaluating in-situ versus ex-situ treatment (Part I), the main issue under effectiveness is the ability of the component to achieve background levels. Excavation of the contaminated soil and replacement with treated or clean soil would achieve background conditions. In contrast, soil vapor extraction approaches background over time, while product collection trenches leave a significant residual. Based on these observations, components S-1 through S-4 receive a good rating because all contaminated areas achieve or approach background, whereas component S-5 receives a poor rating due to significant residuals which remain following in-situ product recovery.

The main issues under reliability are 1) excavation results in the greatest short-term certainty of success except in the Tank Farm Area where the extent of excavation is limited near building for structural reasons, 2) excavation results in the lowest long-term certainty of success due to the high potential for recontamination by groundwater, and 3) excavation is the most reliable means for recovery of separate phase product. Component S-4 receives a good rating for reliability in that the SVE systems in the Tank K and Tank Farm areas can handle potential recontamination which may result because these are areas of highest groundwater contamination, and the Eastern Parking Lot is excavated resulting in a greater certainty of success because the separate phase product is removed. Components S-1, S-2, and S-3 received fair ratings because areas exist which are subject to potential recontamination without a treatment system in place to address it.

The key differences under implementability are technical complexity, ability of the component to be integrated into the existing facility operations, monitoring, and the extent of operations and maintenance (O&M). Components S-2 and S-4 receive good ratings for the following reasons: 1) soil vapor extraction in the Tank Farm is less complex than excavation (components S-1 and S-3 involve excavation of the Tank Farm Area) due to the underground piping and utilities, 2) excavation of the Eastern Parking Lot is less complex

Effectiveness

Reliability

Implementability

Table 4-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 **Excavate All Soil and Sediment**	**S-2** **Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment**	**S-3** **Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment**	**S-4** **Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment**	**S-5** **Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment**
1. Effectiveness					
a. Temporary or Permanent	• Permanent	• Permanent	• Permanent	• Permanent	• Permanent
b. Reuse, Recycling, Destroying, Detoxifying or Treating On-Site	• For all excavated soils (Tank K, Tank Farm/Drum Storage, Eastern Parking Lot, Outfall 001), depends on treatment option selected	• Soil vapor extraction (SVE) at Tank Farm represents on-site treatment • For all excavated soils (Tank K, Drum Storage, Eastern Parking Lot, Outfall 001), depends on treatment option selected	• Soil vapor extraction at Tank K represents on-site treatment • For all excavated soils (Tank Farm/Drum Storage, Eastern Parking Lot, Outfall 001), depends on treatment option selected	• Soil vapor extraction at Tank K and Tank Farm represents on-site treatment • For all excavated soils (Drum Storage, Eastern Parking Lot, Outfall 001), depends on treatment option selected	• Soil vapor extraction at Tank K, Tank Farm, and Eastern Parking Lot represents on-site treatment • For all excavated soils (Drum Storage and Outfall 001), depends on treatment option selected

Table 4-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 **Excavate All Soil and Sediment**	**S-2** **Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment**	**S-3** **Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment**	**S-4** **Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment**	**S-5** **Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment**
c. Achieve or Approach Background	• Achieve background levels in areas which are excavated	• Achieve background levels in areas which are excavated • Approach background levels in areas with SVE	• Achieve background levels in areas which are excavated • Approach background levels in areas with SVE	• Achieve background levels in areas which are excavated • Approach background levels in areas with SVE	• Achieve background levels in areas which are excavated • Approach background levels in areas with SVE • Significant residuals, below cleanup levels, in area with product collection trench
Effectiveness Rating	G	G	G	G	P
2. Reliability a. Short Term Certainty of Success	• Excavation has the greatest short-term certainty of success • Extent of excavation near buildings is limited for structural reasons in Tank Farm	• In Tank Farm, SVE has lower short-term certainty of success	• In Tank K, SVE has lower short-term certainty of success • Extent of excavation near buildings is limited for structural reasons in Tank Farm	• In Tank K and Tank Farm, SVE has lower short-term certainty of success	• In Tank K, Tank Farm, and Eastern Parking Lot, SVE has lower short-term certainty of success

Table 4-3
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	S-2 Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	S-3 Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	S-4 Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	S-5 Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
b. Long-Term Certainty of Success	• In Tank K and Tank Farm, excavation has the lowest long-term certainty of success due to the potential for recontamination by groundwater • In the Eastern Parking Lot, excavation has the greatest long-term certainty of success to recover product	• In Tank Farm, SVE has highest long-term certainty of success because it can handle potential recontamination • In Tank K, excavation has the lowest long-term certainty of success due to potential for recontamination by groundwater • In Eastern Parking Lot, excavation has the greatest long-term certainty of success to recover product	• In Tank K, SVE has highest long-term certainty of success because it can handle potential recontamination • In Tank Farm, excavation has the lowest long-term certainty of success due to potential for recontamination by groundwater • In Eastern Parking Lot, excavation has the greatest long-term certainty of success to recover product	• In Tank K and Tank Farm, SVE has highest long-term certainty of success because it can handle potential recontamination • In Eastern Parking Lot, excavation has the greatest long-term certainty of success to recover product	• In Tank K, Tank Farm and Eastern Parking Lot, SVE has highest long-term certainty of success because it can handle potential recontamination. • In Eastern Parking Lot, interceptor trenches have the lowest long-term certainty of success to recover product
c. Measures to Manage Residuals	None required	None required	None required	None required	None required

Table 4-3
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	**S-2** Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	**S-3** Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	**S-4** Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	**S-5** Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
d. Measures to Control Emissions or Discharges	• For excavation, air emissions not controlled • For excavation, effective measures for handling runoff and treatment of groundwater from excavation dewatering are needed	• For excavation, air emissions not controlled • For excavation, effective measures for handling runoff and treatment of groundwater from excavation dewatering are needed • For SVE, effective measures for treating extracted soil gas are needed	• For excavation, air emissions not controlled • For excavation, effective measures for handling runoff and treatment of groundwater from excavation dewatering are needed • For SVE, effective measures for treating extracted soil gas are needed	• For excavation, air emissions not controlled • For excavation, effective measures for handling runoff and treatment of groundwater from excavation dewatering are needed • For SVE, effective measures for treating extracted soil gas are needed	• For excavation, air emissions not controlled • For excavation, effective measures for handling runoff and treatment of groundwater from excavation dewatering are needed • For SVE, effective measures for treating extracted soil gas are needed
Reliability Rating	F	F	F	G	P

Table 4-3
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	**S-2** Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	**S-3** Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	**S-4** Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	**S-5** Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
3. Implementability					
a. Technical Complexity	• Excavation in Tank K and Eastern Parking Lot is less complex than SVE • Excavation of Tank Farm Area is more complex than SVE because of extensive utilities	• Excavation in Tank K and Eastern Parking Lot is less complex than SVE • SVE of Tank Farm Area is less complex than excavation	• SVE in Tank K is more complex than excavation • Excavation in Eastern Parking Lot is less complex than SVE • Excavation in Tank Farm is more complex than SVE because of extensive utilities	• SVE in Tank K is more complex than excavation • Excavation in Eastern Parking Lot is less complex than SVE • SVE in Tank Farm is less complex than excavation	• SVE in Tank K is more complex than excavation • SVE/Product Collection Trenches in Eastern Parking Lot is more complex than excavation • SVE in Tank Farm is less complex than excavation
b. Integration with Facility Operations	• Excavation of Tank Farm Area is disruptive to a high use area of existing facility	• SVE in Tank Farm is more easily integrated with existing operations	• Excavation of Tank Farm Area is disruptive to a high use area of existing facility	• SVE in Tank Farm is more easily integrated with existing operations	• SVE in Tank Farm is more easily integrated with existing operations
c. Monitoring, O&M or Site Access Requirements/Limitations	• Excavation does not require any long-term monitoring or O&M	• SVE requires monitoring and O&M	• SVE requires monitoring and O&M	• SVE requires monitoring and O&M	• SVE requires monitoring and O&M • Product collection trenches require long-term monitoring and O&M
d. Availability of Services	• Necessary equipment for excavation readily available	• SVE equipment readily available	• SVE equipment readily available	• SVE equipment readily available	• SVE equipment readily available

Table 4-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	**S-2** Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	**S-3** Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	**S-4** Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	**S-5** Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
e. Availability of Off-Site TSD Facilities	• Availability of off-site TSD facilities dependent on treatment option chosen	• SVE eliminates need for off-site TSD facilities for soils from the Tank Farm Area • Availability of off-site TSD facilities for excavated soil dependent on treatment option chosen	• SVE eliminates need for off-site TSD facilities for soils from the Tank K Area • Availability of off-site TSD facilities for excavated soil dependent on treatment option chosen	• SVE eliminates need for off-site TSD facilities for soils from the Tank Farm and Tank K Areas • Availability of off-site TSD facilities for excavated soil dependent on treatment option chosen	• SVE eliminates need for off-site TSD facilities for soils from Tank K, Tank Farm, and Eastern Parking Lot • Availability of off-site TSD facilities for excavated soil dependent on treatment option chosen
f. Permits	• Permits dependent on treatment option chosen	• Permit for off-gas treatment from SVE system may be required • Additional permits dependent on treatment option chosen	• Permit for off-gas treatment from SVE system may be required • Additional permits dependent on treatment option chosen	• Permit for off-gas treatment from SVE system may be required • Additional permits dependent on treatment option chosen	• Permit for off-gas treatment from SVE system may be required • Additional permits dependent on treatment option chosen
Implementability Rating	F	G	F	G	F

Table 4-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	**S-2** Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	**S-3** Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	**S-4** Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	**S-5** Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
4. Cost					
a. Cost of Implementation	$4.0 - $4.3 million	$4.1 - $4.4 million	$3.1 - $3.3 million	$3.2 - $3.4 million	$4.8 - $5.0 million
b. Cost of Restoration	• Equally addresses wetland sediment	• Equally addresses wetland sediment	• Equally addresses wetland sediment	• Equally addresses wetland sediment	• Equally addresses wetland sediment
c. Cost of Energy Consumption	• Excavation/treatment and SVE have similar energy consumption	• Excavation/treatment and SVE have similar energy consumption	• Excavation/treatment and SVE have similar energy consumption	• Excavation/treatment and SVE have similar energy consumption	• Excavation/treatment and SVE have similar energy consumption
Cost Rating	F	F	G	G	P
5. Risk					
a. Risk During Implementation	• Greater short-term risk to construction workers for excavation than for SVE installation • Risk to construction workers associated with potential for broken utilities in Tank Farm excavation	• Lower short-term risk to construction workers for SVE installation than for excavation	• Lower short-term risk to construction workers for SVE installation than for excavation • Risk to construction workers associated with potential for broken utilities in Tank Farm excavation	• Lower short-term risk to construction workers for SVE installation than for excavation	• Lower short-term risk to construction workers for SVE installation than for excavation

Table 4-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	**S-2** Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	**S-3** Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	**S-4** Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	**S-5** Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
b. Risk During Operations	• No long-term risk associated with excavation	• Potential slight long-term risk associated with emission from SVE system	• Potential slight long-term risk associated with emission from SVE system	• Potential slight long-term risk associated with emission from SVE system	• Potential slight long-term risk associated with emission from SVE system
c. Risks Associated with Residuals	• No risk, cleanup levels attained	• No risk, cleanup levels attained	• No risk, cleanup levels attained	• No risk, cleanup levels attained	• Potential risk due to residual product in Eastern Parking Lot
Risk Rating	F	G	G	G	F
6. Benefits					
a. Restores Natural Resources	• Restores aquifer	• Restores aquifer	• Restores aquifer	• Restores aquifer	• Potential continued impact to groundwater due to residual product
b. Achieves Productive Reuse of Site	• Achieves productive reuse	• Achieves productive reuse	• Achieves productive reuse	• Achieves productive reuse	• Achieves productive reuse

Table 4-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART I - IN-SITU/EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	**S-2** Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	**S-3** Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	**S-4** Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	**S-5** Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
c. Avoids Cost of Relocation or Provision of Alternate Water Supply	• N/A	• N/A	• N/A	• N/A	• N/A
d. Avoids Lost Value	• Avoids lost value of site	• Avoids lost value of site	• Avoids lost value of site	• Avoids lost value of site	• Potential for lower value due to residual product
Benefits Rating	G	G	G	G	F
7. Timeliness a. Time to Achieve Objectives	6 - 12 months	8 years	3 years	8 years	15 years
Timeliness Rating	G	F	G	F	F
8. Non-Pecuniary a. Aesthetics	• No long-term treatment facilities on-site	• Long-term treatment facilities on-site	• Long-term treatment facilities on-site	• Long-term treatment facilities on-site	• Long-term treatment facilities on-site
Non-Pecuniary Rating	G	F	F	F	F

Note: MF - Most Favorable, G - Good, F - Fair, P - Poor

Table 4-4

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION SUMMARY
(PART I - EX-SITU/IN-SITU TREATMENT)

Evaluation Criteria	Soil Component Description				
	S-1 Excavate All Soil and Sediment	S-2 Vapor Extraction (Tank Farm), Excavate Remaining Soil and Sediment	S-3 Vapor Extraction (Tank K), Excavate Remaining Soil and Sediment	S-4 Vapor Extraction (Tank K and Tank Farm), Excavate Remaining Soil and Sediment	S-5 Vapor Extraction (Tank K, Tank Farm, Eastern Parking Lot), Product Collection Trenches (Eastern Parking Lot), Excavate Remaining Soil and Sediment
1. Effectiveness	G	G	G	G	P
2. Reliability	F	F	F	G	P
3. Implementability	F	G	F	G	F
4. Cost	F	F	G	G	P
5. Risk	F	G	F	G	F
6. Benefit	G	G	G	G	F
7. Timeliness	G	F	F	F	F
8. Non-Pecuniary	G	F	F	F	F
Selected Component				X	

Note: G - Good, F - Fair, P - Poor

Table 4-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SOIL COMPONENT EVALUATION
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
1. Effectiveness				
a. Temporary or Permanent	• Permanent	• Permanent	• Permanent	• Permanent
b. Reuse, Recycling, Destroying, Detoxifying or Treating On-Site	• Destroys and reuses on-site	• Destroys off-site	• Recycles on-site	• Recycles off-site
c. Achieve or approach background	• Approaches background	• Approaches background	• Approaches background	• Approaches background
Effectiveness Rating	G	F	G	F
2. Reliability				
a. Certainty of success	• Less certainty of success than off-site	• Higher certainty of success than on-site because operation is at an established facility	• Less certainty of success than off-site	• Higher certainty of success than on-site because operation is at an established facility

Table 4-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION (PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
b. Measures to manage residuals	• N/A	• N/A	• N/A	• N/A
c. Measures to control emissions or discharges	• Effective treatment of off-gases	• Effective treatment of off-gases	• Some release of volatiles	• Effective treatment of off-gases
Reliability Rating	F	G	F	G
3. Implementability				
a. Technical Complexity	• Complexity greater on-site due to staging requirements, containment of runoff from stockpiles, vapor release issues	• Less complex off-site at an established facility, but requires transportation	• Complexity greater on-site due to staging requirements, containment of runoff from stockpiles, vapor release issues • Potential for unacceptable VOC levels (limited areas) which may prohibit use of option	• Less complex off-site at an established facility, but requires transportation • Potential for unacceptable VOC levels (limited areas) which may prohibit use of option

Table 4-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SOIL COMPONENT EVALUATION
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
b. Integration with facility operations	• Greater potential for disruption to facility operations due to equipment/operation and stockpiling of soil	• Less disruption than on-site treatment	• Greater potential for disruption to facility operations due to equipment/operation and stockpiling of soil • Potential difficulty in raising the parking lot by 9" - 10" (significant drainage issues)	• Less disruption than on-site treatment
c. Monitoring, O&M or site access requirements/limitations	• No monitoring, O&M or access issues	• No monitoring, O&M or access issues	• Potential need for monitoring to evaluate leaching. No O&M or access issues	• No monitoring, O&M or access issues
d. Availability of Services	• Limited (two firms identified locally)	• Limited (two firms identified locally)	• Readily available	• Greater availability than on-site
e. Availability of off-site TSD facilities	• N/A	• Limited (two firms identified locally)	• N/A	• Readily available

Table 4-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
f. Permits	• Air discharge permit required	• Facility has necessary permits	• Operations permit required	• Facilities have necessary permits, variance required for Stoddard solvent
Implementability Rating	F	G	F	F
4. Cost				
a. Cost of implementation	• $3.2 million	• $3.3 million	• $3.4 million	• $3.2 million • Potential for competitive bids from wide variety of vendors to decrease cost
b. Cost of Restoration	• Low potential for impact to surface water due to runoff from stockpiles	• N/A	• Low potential for impact to surface water due to runoff from stockpiles	• N/A

Table 4-5
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
c. Cost of Energy Consumption	• Higher consumption of energy than asphalt batching	• Higher consumption of energy than asphalt batching • Higher consumption of energy than on-site due to transportation	• Lower consumption of energy than thermal desorption	• Lower consumption of energy than thermal desorption • Higher consumption of energy than on-site due to transportation
Cost Rating	G	G	G	G
5. Risk				
a. Risk during implementation	• Risk associated with use of heavy equipment on-site	• Risk associated with use of heavy equipment on-site and transporting large quantities of soil off-site (potential spilling)	• Risk associated with use of heavy equipment on-site • Minimal vapor releases during batching and paving operations	• Risk associated with use of heavy equipment on-site and transporting large quantities of soil off-site (potential spilling)
b. Risk during operations	• N/A	• N/A	• N/A	• N/A

Table 4-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
c. Risk associated with residuals	• Low residual which meets cleanup goal, no risk	• No residual, material removed off-site	• Hazardous material still on-site, however, it is stabilized and meets Land Disposal Regulations, low risk	• No residual, material removed off-site
Risk Rating	G	G	G	G
6. Benefits				
a. Restores natural resources	• Restores resources	• Restores resources	• Restores resources	• Restores resources
b. Achieves productive reuse of site	• Achieves productive reuse	• Achieves productive reuse	• Achieves productive reuse	• Achieves productive reuse
c. Avoids cost of relocation or provision of alternate water supply	• N/A	• N/A	• N/A	• N/A

Table 4-5
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SOIL COMPONENT EVALUATION
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Treatment of Soils Excavated from the Eastern Parking Lot, Drum Storage and Sediment from Outfall 001			
	Thermal Desorption		Asphalt Batching	
	On-Site	Off-Site	On-Site	Off-Site
d. Avoids lost value of site	• Avoids lost value	• Avoids lost value	• The fact that asphalt contains the hazardous material may slightly detract from site value	• Avoids lost value
Benefits Rating	G	G	F	G
7. Timeliness				
a. Time to achieve objectives	6 - 12 months	6 - 12 months	6 - 12 months	6 - 12 months
Timeliness Rating	G	G	G	G
8. Non-Pecuniary				
a. Aesthetics	• All operations on-site	• Truck traffic	• All operations on-site	• Truck traffic
Non-Pecuniary Rating	G	F	G	F

Note: G - Good, F - Fair, P - Poor

Table 4-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTHREADING, MASSACHUSETTS

REMEDIAL ACTION PLAN

SOIL COMPONENT EVALUATION SUMMARY
(PART II - EX-SITU TREATMENT)

Evaluation Criteria	Soil Component Description			
	On-Site Thermal Desorption	Off-Site Thermal Desorption	On-Site Asphalt Batching	Off-Site Asphalt Batching
1. Effectiveness	G	F	G	F
2. Reliability	F	G	F	G
3. Implementability	F	G	F	F
4. Cost	G	G	G	G
5. Risk	G	G	G	G
6. Benefit	G	G	F	G
7. Timeliness	G	G	G	G
8. Non-Pecuniary	F	F	F	F
Selected Component	*	X	*	*

Note: G - Good, F - Fair, P - Poor

X: Selected Component
*: Components which remain applicable, dependent on further soils testing

than soil vapor extraction/product collection (component S-5 involves SVE/product collection in Eastern Parking Lot), and 3) soil vapor extraction in the Tank Farm area is more easily integrated with operations at the facility. Although these components require more monitoring and O&M than component S-1, the advantages described above are considered more important.

The major issue for cost is the cost of implementation (construction and O&M). The present worth costs for S-3 and S-4 ($3.1 - 3.4 million) are significantly lower than those for the other three components ($4.0 - 5.0 million) and therefore both of these components receive a good rating.

The issues under the risk criteria are risks during construction and risks associated with residuals. Components S-2 and S-4 receive good ratings because: 1) there is lower short term risk to construction workers in implementing SVE than excavation particularly in the Tank Farm Area (i.e., components S-1 and S-3 include excavation in the Tank Farm Area), and 2) there is no risk associated with residuals as in component S-5. Although these components have potential long term risk associated with emissions from SVE systems (compared to S-1), the risk is considered minor given that there will be emission controls.

Under the criteria for benefits, the only component which does not receive a good rating is component S-5 because there is a potential loss of property value due to residual product not removed by the vapor extraction/trench system in the Eastern Parking Lot.

With regards to timeliness, excavation of all contaminated material receives a good rating because it would be completed in less than a year. In contrast, soil vapor extraction significantly increases the time of remediation (3 - 15 years). However, all of these time periods are below the estimated time for groundwater remediation, and as a result are considered acceptable.

The final criteria, non-pecuniary, deals with aesthetics. The component S-1 receives a good rating in that no-long term structures (i.e., buildings for SVE treatment equipment) are associated with this component.

The ratings assigned to each of the above criteria are summarized in Table 4-4. Soil component S-5 can be eliminated because it received either fair or poor ratings under all criteria. Components S-1 through S-4 all meet the majority of criteria with good or fair rankings. As a result, their selection can be based primarily on cost. Components S-1 and S-2 can be eliminated because they have significantly higher costs (30% higher than components S-3 and S-4). Components S-3 and S-4 have essentially equivalent costs, however, soil component S-4 has the following advantages over component S-3:

1. It has soil vapor extraction systems which can address both areas (Tank K and Tank Farm) where there is potential for recontamination of soil, and
2. It avoids excavation in a high use area (Tank Farm) which could be very disruptive to existing operations, and avoids potential interference with numerous underground pipes and utilities and the associated risks with construction activities.

Based on this evaluation, S-4 (Vapor Extraction at Tank K and Tank Farm, Excavation of Remaining Soil and Sediment) is selected as the most favorable component.

4.4.2 Ex-Situ Treatment Evaluation

The following discussion consists of an evaluation of the most favorable ex-situ treatment for the soils and sediment excavated under soil component S-4. The four treatment components that are evaluated (see Table 4-5) are on- and off-site thermal desorption and on- and off-site asphalt batching.

In evaluating the four treatment components, the main issue under effectiveness is whether or not the treatment occurs on-site, given that all options will approach background levels. For this reason, on-site thermal desorption and on-site asphalt batching receive good ratings.

The main issue under reliability is that established facilities have a greater certainty of success than mobile units. Therefore, off-site thermal desorption and off-site asphalt batching receive good ratings.

Off-site thermal desorption received a good implementability rating for the following reasons: 1) off-site treatment at an established facility is, in general, less complex than on-site treatment, 2) off-site treatment is less disruptive to the existing facility, 3) established facilities already possess the necessary permits and 4) thermal desorption can handle higher levels of chlorinated compounds (100 ppm vs. 1 ppm) and BTEX compounds than asphalt batching (allowing greater flexibility to handle all excavated soil and sediment).

The cost criteria shows no clear advantage for any of the options and therefore all received a good rating. Similarly, there was no clear distinction between the components under the risk criteria and all received a good rating. The only significant difference under the benefit criteria is that on-site asphalt batching leaves the material on-site in a stabilized form which may slightly detract from site value. The time required to achieve objectives under each component is approximately the same (6 - 12 months) and therefore all were rated good. Off-site treatment (thermal desorption or asphalt batching) receives a fair rating for aesthetics due to the extensive truck traffic which will result from transporting the soil off-site. Likewise the on-site treatment options also received fair ratings due to the stockpiling and equipment associated with on-site treatment.

The results of this evaluation of soil treatment components is summarized in Table 4-6. Due to the uncertainty of the levels of chlorinated compounds in the Eastern Parking Lot and Drum Storage Area soil (both of which exhibited tetrachloroethene and trichloroethene in the soil gas) the selection of thermal desorption assures that all excavated soils and sediment can be addressed. Off-site thermal desorption has the following advantages over on-site: 1) the remediation activities are less complex and more reliable at an established facility and 2) less disruption will occur to existing operations. Based on this evaluation, the selected treatment component is off-site thermal desorption. It should be noted, however, that all four soil treatment components ranked nearly equally, and that additional information collected prior to implementation could shift the selection toward one of the other three components. As a result, this feasibility study leaves open the option of implementation of the other three components.

In summary, the selected soil component is soil vapor extraction at Tank K and Tank Farm, excavation of the Eastern Parking Lot, Drum Storage Area and Outfall 001, and off-site thermal desorption treatment of excavated soils and sediment.

4.5 DEVELOPMENT OF GROUNDWATER COLLECTION COMPONENTS

4.5.1 Simulation of the Groundwater Flow System

The purpose of this modeling was to determine whether the proposed location of groundwater control systems are appropriate and adequate to effectively contain, intercept and recover the contaminated groundwater. A three-dimensional numerical groundwater flow model was used to simulate the aquifer response to various pumping components and thereby determine optimum numbers and locations of groundwater recovery wells.

4.5.1.1 Remedial Model

Remedial modeling for the groundwater on-property involved the simulation of groundwater hydraulic capture zones and downgradient hydraulic barriers created by recovery wells to address four source area locations: the Tank Farm Area, the Eastern Parking Lot Area, the Tank F Area and the Tank K Area (see Figure 4-2). The modeling also addressed the hydraulic capture zones for groundwater beneath the wetlands east of the property.

Two flow models were created to examine flow characteristics of the area. A small scale model (using uniform 40 foot cells) was used to examine the regional groundwater flow characteristics of the site (see Figure 4-2). A larger scale model was created to simulate the flow conditions at the Tank K Area only (see Figure 4-3).

The larger scale model was necessary for the Tank K Area due to the geology and distribution of contaminants in this location. Results from the hydrogeological investigation showed that the distribution of groundwater VOCs was restricted to the shallow overburden materials and that these materials are fine-grained. A smaller grid spacing (5 foot uniform cells) was required to properly simulate the sharp drawdown effects resulting from extracting groundwater from the fine-grained materials in this upper zone.

The overburden and bedrock aquifers were simulated using MODFLOW, a finite-difference, three-dimensional numerical groundwater flow model and MODPATH, a particle tracking model, developed by the United States Geological Survey (USGS). The flow models simulate groundwater flow in the aquifer under steady state conditions and once calibrated, can be used to simulate long term changes to aquifer development due to pumping. The particle tracking model was then coupled to the flow model to evaluate pathlines and estimated travel times of groundwater flow through various parts of the flow regime. The particle tracker was also used to delineate zones of influence (capture zones) to groundwater recovery areas.

The simple mixed linear reservoir or "batch flush" model was then used to estimate the number of flushes of groundwater (pore volumes) through a contaminated aquifer required to achieve cleanup objectives. The calculated travel times from the particle tracking model results were used in conjunction with these pore volume estimates to estimate the time required to achieve the cleanup objectives.

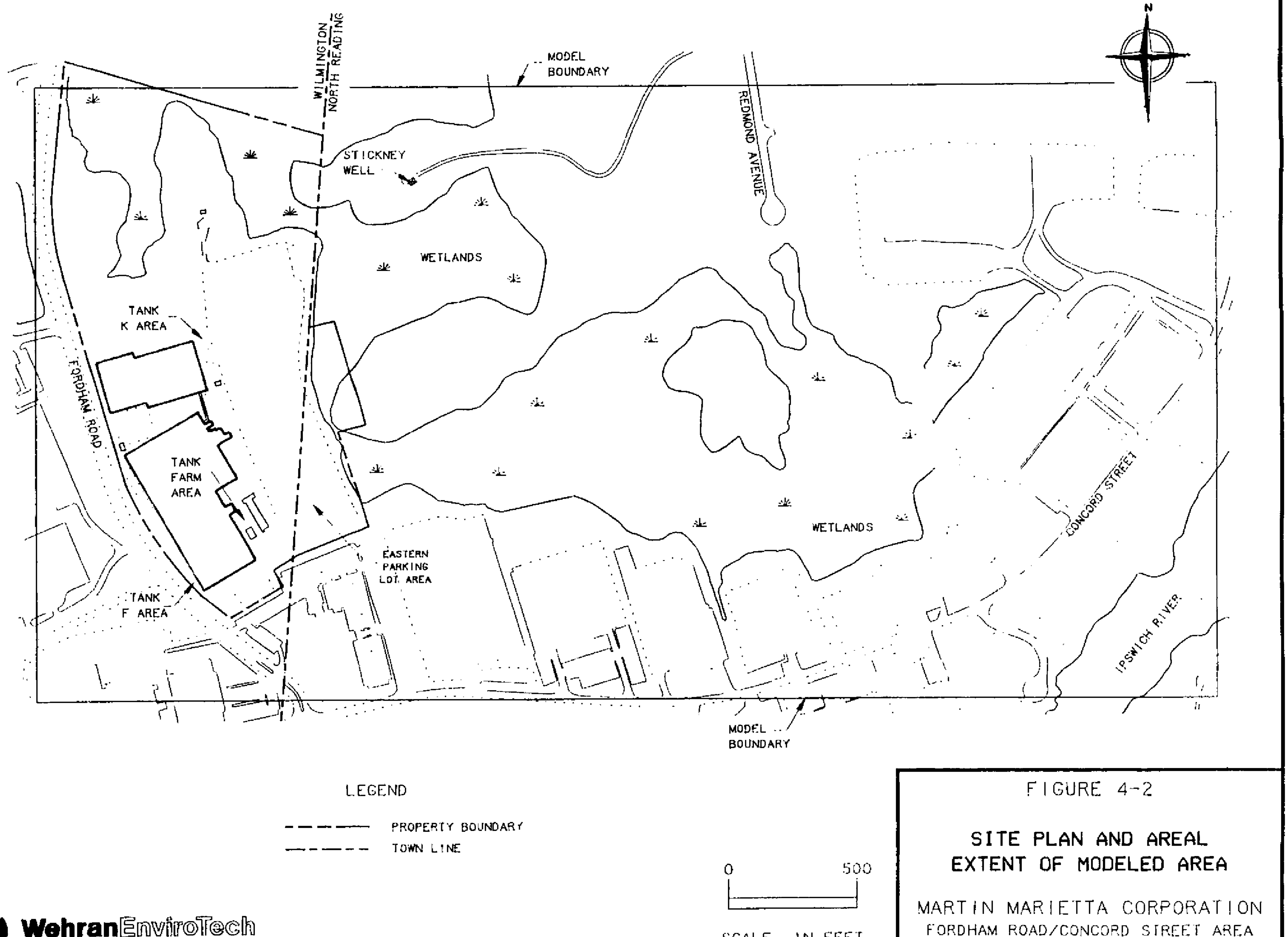

FIGURE 4-2

SITE PLAN AND AREAL EXTENT OF MODELED AREA

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FORDHAM ROAD/CONCORD STREET AREA
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It should be noted that these estimated cleanup times are based on a wide variety of assumptions. The first set of assumptions relate to the hydrogeologic properties used to develop the flow model, for example; hydraulic conductivity, aquifer thickness, recharge, boundary conditions, etc. These assumptions are based on hydrogeologic properties measured in the field, and as noted in section 1.5, there are uncertainties associated with data compiled from a variety of sources using different methods of data collection. More importantly, these properties are based on a limited amount of data from widely spaced data points. The second set of assumptions relates to properties used in the batch flush model, for example; effective porosity and fraction organic carbon. Given this wide variety of assumptions, the estimated cleanup times should be considered only approximations. These estimates are, however, extremely useful for comparing relative cleanup times between various extraction scenarios.

MODFLOW uses a finite-difference grid to divide the model areas into discrete blocks. The model uses a block-centered scheme which performs equation calculations at the center of each block (referred to as the node). Averaged aquifer properties and hydraulic stresses for the block area are specified at each node.

Data input to MODFLOW consists of (1) dimensions of each block, (2) altitude of land surface, (3) hydraulic head/water level, (4) altitude of the aquifer base(s), (5) hydraulic conductivity, (6) hydraulic stresses, such as rate of groundwater recharge, and discharge by pumpage, and (7) hydrogeologic boundaries. The model simulates unconfined and convertible (confined to unconfined) aquifers; therefore, transmissivity is computed by the model as a product of hydraulic conductivity and saturated thickness. The model, in turn, calculates saturated thickness as the difference between the aquifer's base and the hydraulic head to account for changes in transmissivity as a result of aquifer dewatering or head buildup.

Hydrologic boundaries are specified by selecting one of the following boundary conditions: (1) constant hydraulic head at the boundary, (2) constant flux across the boundary, or (3) head-dependent flux across the boundary. At constant-head boundaries, the model maintains initial water levels at the boundary by allowing enough water to enter the model to satisfy imposed stresses. By contrast, a constant-flux boundary allows a predetermined amount of water to flow across the boundary, an amount that does not change in response to simulated stresses. The constant flux boundary may be set to zero to simulate an impermeable boundary or it may have a finite value to simulate leakage across the boundary. If it has a large finite value, it approximates a constant-head boundary. The head-dependent flux allows the model to determine the flux into or out of the aquifer on the basis of the transmissivity and the difference between a model-computed head in the aquifer and a specified fixed head on the other side of a leaky layer at the boundary.

4.5.1.2 Development of Model

The model simulates groundwater flow in the vicinity of the 50 Fordham Road property and the wetlands to the Ipswich River. Figure 4-2 shows the areal extent of the modeled area which includes the stratified drift buried glacial valley aquifer and the fractured bedrock zone beneath it. Natural hydrogeologic boundaries, such as the bedrock uplands to the west and north, the bedrock ridge along Concord Street, and the Ipswich River determined the horizontal and vertical extents of the modeled area.

The permeable fractured bedrock consisted of the upper weathered zone and was simulated as an equivalent porous medium. That is, it was assumed that the fractured material could be treated as a continuum and that a representative elementary volume (grid block) of material could be characterized by uniform hydraulic parameters. It should be recognized that this is a standard simplification for the modeling of bedrock, and that in reality the fractures will cause variable hydraulic properties.

The regional model consists of a 7,200 block (120 x 60) grid with a uniform spacing of 40 feet on a side (in map view). Each block represents 1,600 square feet (ft^2) in map view. The long axis of the model grid is approximately parallel to the primary direction of groundwater flow. The upper boundary of the model is defined by the shallow overburden water table and the bottom boundary is defined by relatively low-yielding bedrock. The average elevation (relative to mean sea level) of the upper boundary is 75 feet, whereas, the lower boundary is set at an elevation of -40 feet.

The regional model is divided into four layers corresponding roughly to the stratigraphic layers found in the wetlands located east of the property. From top to bottom the layers consist of: 1) a fill/peat layer, 2) an outwash (silty sand) layer, 3) an ice-contact (sand and gravel) layer, and 4) a permeable fractured bedrock layer. The total modeled depth averaged 120 feet and the layer thicknesses, from top to bottom, were 15 (an average is given for the top layer since the top of the model is the water table which fluctuates in elevation), 20, 35 and 50 feet, respectively. The spatial variability in the types of strata found at the site were simulated by defining the appropriate aquifer parameters for those nodes which corresponded to the type of strata found at a particular horizontal or vertical location. For example, in those locations where outcrops occurred, that vertical column of the model consisted of 4 layers of blocks with aquifer properties which corresponded to permeable fractured bedrock only.

The Tank K Area model simulates groundwater flow in the vicinity of the Tank K Area on the property. Figure 4-3 shows the areal extent of the modeled area which includes the area between Building 2 and the downgradient wetlands. The model consisted of one layer which simulated the silty sand at this locality. The bottom boundary of the model was assumed to be impervious bedrock. Jim → ok?

The Tank K Area model consists of a 7,200 block (100 x 72) grid with a uniform spacing of 5 feet on a side (in map view). Each block represents 25 square feet (ft^2) in map view. The long axis of the model grid is approximately parallel to the primary direction of groundwater flow. The upper boundary of the model is defined by the shallow overburden water table and the bottom boundary is defined by bedrock. The average elevation (relative to mean sea level) of the upper boundary is 77 feet, whereas, the lower boundary ranges from 30 to 50 feet.

Hydrologic boundaries in the model were simulated using constant-head, constant-flux, no-flux, and head-dependent boundary types. Constant heads were assigned to blocks representing areas where water enters or leaves the system as streamflow (Ipswich River). Constant-flux boundaries with zero flux were used to simulate "no flow" conditions at the bottom of the model where flow from the deep, relatively competent low-yielding bedrock is an insignificant part of the hydrologic budget because of the relatively low values of hydraulic conductivity. Head-dependent boundaries were used to simulate baseflow into and out of the model along the lateral extent of the model.

4.5.1.3 Model Calibration

The models were calibrated to equilibrium (steady state) conditions, but there was insufficient historical water-level data in the modeled area to calibrate the models to transient conditions. The steady-state calibrations were made by successively adjusting

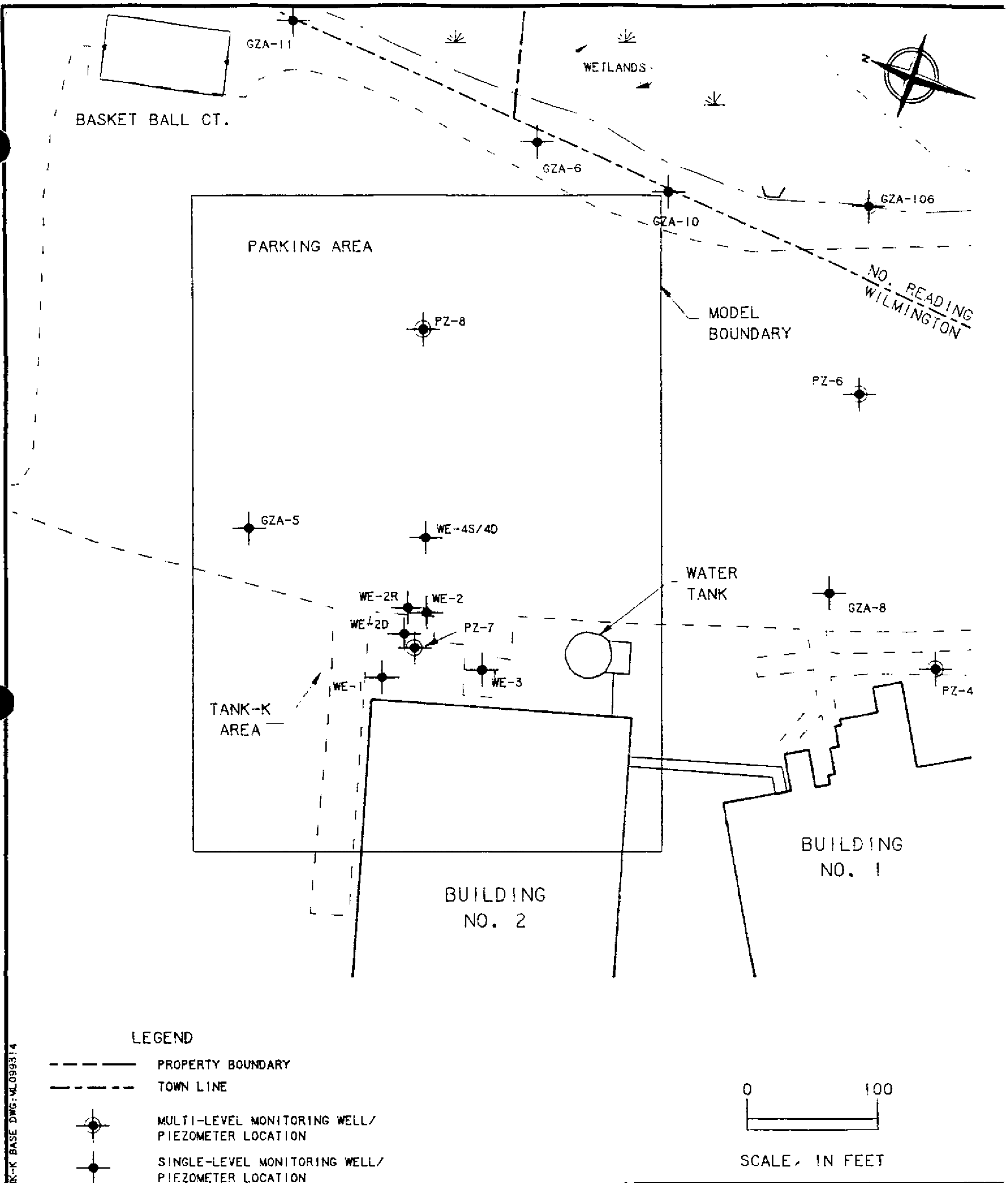

FIGURE 4-3

TANK-K MODEL, AREAL EXTENT OF MODELED AREA

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input variables within reasonable limits consistent with the conceptual model until model-calculated water levels were within plus or minus 1.0 foot of April 13, 14 and 15, 1992, groundwater levels at nodes with observation wells. Upon calibration of the models to the current aquifer conditions, the models were used to simulate aquifer response to stress conditions representing schemes for groundwater collection (pumpage). The lack of historical water level data causes the models, as presently constructed, to be restricted to simulating steady-state conditions. Steady-state models, however, simulate long-term, worst-case drawdown effects and, therefore, provide a conservative long-term portrayal of groundwater collection.

The regional model was calibrated with the following variables: (1) groundwater pumpage, (2) groundwater recharge, (3) evapotranspiration, (4) hydraulic conductivity of the aquifer, and (5) travel times of contaminants. The pump test data used in the calibration included the Stickney Well data collected by CDM in 1964, and groundwater hydraulic data collected by Wehran for the bedrock recovery well TF-1 located in the Tank Farm Area. The regional model was calibrated by ensuring that the travel times of groundwater particles were within 5 years of the estimated travel time of conservative contaminants. This was accomplished by calculating the approximate linear or pore velocity of bulk groundwater flow in the area and comparing that to the approximate time of release and the furthest downgradient extent of contamination. This value was then compared to the particle tracker results for consistency.

The Tank K model was calibrated with the following variables: (1) groundwater pumpage, (2) groundwater recharge, (3) hydraulic conductivity of the aquifer, and (4) travel times of contaminants. This model was calibrated to slug-test data collected by Wehran for the overburden monitoring wells located in the Tank K Area. The model was also calibrated by ensuring that the travel times of groundwater particles were within 1 year of the estimated travel time of conservative contaminants.

During model simulations at the locations proposed for the groundwater recovery wells, the pumping components were considered optimal when overlapping cones of depression created a groundwater drawdown of at least one-foot between the proposed recovery wells. It is Wehran's experience that in developing an effective groundwater pump and treat recovery system, that at least one-foot of drawdown be observed between the overlapping cones of depression of the recovery wells to ensure that the contaminated groundwater is captured and contained by the remedial system. During these pumping/containment components, Wehran ran numerous simulations in an attempt to minimize the number of recovery wells and pumping rates used to capture the contaminated groundwater. (The effectiveness of these capture zones was further analyzed by using the particle tracker model to assure that all particles at the edge of a groundwater plume were captured by the proposed recovery wells, both areally and vertically.) These simulations were further modified by simulating various discharge components of treated water into the wetlands to minimize the extent of drawdown caused by pumping of the recovery wells (to minimize the impact to wetlands vegetation). Pumpage rates were varied for each of the components.

A recharge (precipitation infiltration) rate of 20 inches per year (in/yr) and an evapotranspiration rate of 19 in/yr were estimated for the regionally modeled area. There was an acceptable match between computed and observed water levels at observation wells throughout the modeled area when a recharge rate of 20 in/yr was applied over those portions of the model area which were not paved or contained buildings and an evapotranspiration rate of 19 in/yr was applied over the wetlands areas only.

The regional model was only slightly sensitive to regional changes of hydraulic conductivity of the aquifer. Based on existing hydrogeologic data, the hydraulic conductivity of the model was estimated to range from 0.1 to 5 feet per day (ft/d) in the on-property fill unit, from 80 to 125 ft/d in the silty sand/peat units, from 150 to 200 ft/d in the sand and gravel (ice-contact) unit, and from 0.1 to 0.5 ft/d for the fractured bedrock.

The hydraulic conductivity of the Tank K Area overburden deposits was calibrated to 8 ft/d. Slug-test data for these materials gave hydraulic conductivity values which ranged from 4 to 12 ft/d. The variation of the hydraulic conductivity value from 4 to 12 ft/d resulted in minimal changes to the flow system. A recharge rate of 20 in/yr was calibrated for the Tank K Area model.

A comparison of water levels computed by the models to water levels measured at observation well locations indicate an acceptable calibration (i.e., calculated head values are within +/- one foot of measured head values).

Sensitivity analysis for the travel times of groundwater particles released at source areas gives the following calibrated porosities of the geologic materials. The specific yield (effective porosity) of the different strata in the models are calibrated to be 20% for the fill, peat and silty sand units, 23% for the sand and gravel and 0.015% for the fractured bedrock.

4.5.1.4 Batch Flush Model

The application of the mixed linear reservoir or "batch flush" model to the evaluation of remedial alternatives is well documented (e.g., Gelhar and Wilson, 1974; U.S. EPA, 1988; and Zheng, et al., 1991). In this approach the number of pore volumes of clean recharge water which must be circulated through the contaminated zone to achieve cleanup to the required remedial standard is calculated from the relation:

$$PV = -R_f \ln \frac{C_s}{C_i} \qquad (1)$$

where PV is the number of pore volumes of clean recharge water which must be circulated through the contaminated aquifer zone to reduce the concentration of a given constituent from an initial value (C_i) to a cleanup standard value (C_s); and R_f is the retardation coefficient for the target constituent, estimated using the following relation:

$$R_f = 1 + K_{oc} * f_{oc} \frac{d_b}{n_e} \qquad (2)$$

where K_{oc} is the organic carbon partition coefficient; f_{oc} is the fraction organic carbon in the aquifer; d_b is the dry bulk density of the aquifer material; and n_e is the effective porosity of the aquifer. A summary of some of the input parameters used in the batch flush model is given in Table 4-7.

Two compounds were found to drive the cleanup times for different parts of the site. Benzene concentrations were found to require the longest time to achieve the cleanup standard at the Tank K Area due to the following characteristics of benzene: 1) high initial concentration, 2) low cleanup standard, and 3) moderate R_f value. At all other locations, tetrachloroethene (PCE) was found to require the longest time to achieve the designated cleanup level. PCE has the highest initial concentrations and the highest R_f value for any of the dissolved VOC constituents in the modeled area. Initial concentrations for these compounds were derived from the January, 1993 groundwater sampling results.

Table 4-7

MARTIN MARIETTA CORPORATION
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REMEDIAL ACTION PLAN
SUMMARY OF BATCH FLUSH MODEL PARAMETERS

Aquifer Material	F_{oc} (%)	d_b (g/cm^3)	n_e (%)	K_{oc}		R_f	
				Benzene	PCE	Benzene	PCE
Shallow Overburden	1.0	1.80	20	78	N/A	8.02	N/A
Deep Overburden	0.1	1.80	23	N/A	272	N/A	3.13
Fractured Bedrock	0.001	2.35	0.015	N/A	272	N/A	4.26

F_{oc} Fraction Organic Carbon
d_b Dry bulk density (grams per cubic centimeter)
n_e Effective porosity
K_{oc} Organic carbon partition coefficient
R_f Retardation factor
PCE Tetrachloroethenene
g/cm^3 grams per cubic centimeter

The time required to achieve the cleanup objectives under various groundwater collection components was calculated by: 1) simulating the various remedial alternatives; 2) determining the average time required for one pore volume of clean water to flush through the contaminated zone; and 3) multiplying this time by interval by the required number of pore volumes as calculated from equation (1):

$$t_c = PV * t_{PV} \qquad (3)$$

where t_c is the cleanup time; and t_{PV} is the time required for movement of one pore volume of clean groundwater recharge through the contaminated zone.

The batch flush model takes into consideration the transport processes of advection and adsorption only. The model does not account for other processes which could enhance the attenuation of contaminant concentrations, such as dilution, dispersion, chemical reactions, and biodegradation.

4.5.1.5 Selected Groundwater Collection Components

In developing the groundwater collection components of the remedial action alternatives, Wehran simulated numerous combinations of recovery wells to simulate a variety of extraction scenarios both on-property and in the wetlands. Based on these various combinations, Wehran selected three groundwater collection components (which represent a broad range of extraction options) on which to conduct detailed simulations using MODFLOW, MODPATH, the particle tracker and the batch-flush model. In each of the three groundwater collection components, the on-property extraction (i.e., number, location and pumping rates of recovery wells) is identical. The major differences between the three different containment systems involves the presence or absence of recovery wells in the wetlands and the location and volumes of treated water discharged to the wetlands. The purpose of discharging treated water to the wetlands (as surface water) was to: 1) create hydraulic barriers preventing potential off-site migration of contaminants, 2) minimize the amount of dewatering in the wetlands which may potentially impact wetlands vegetation, and 3) enhance cleanup times of contaminated groundwater by increasing the hydraulic gradient of flow to the recovery wells. Under each alternative, the modeling included numerous scenarios in an attempt to achieve each of these objectives.

Table 4-8

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF GROUNDWATER COLLECTION COMPONENTS

Groundwater Collection Component	Location of Groundwater Recovery Systems		
	On-Property	Endpoint of Wetlands	Midpoint and Endpoint of Wetlands
1*	No	No	No
2	Yes	No	No
3	Yes	Yes	No
4	Yes	No	No

* No action

yes yes ?

The following collection components were modeled in detail and are briefly summarized in Table 4-8.

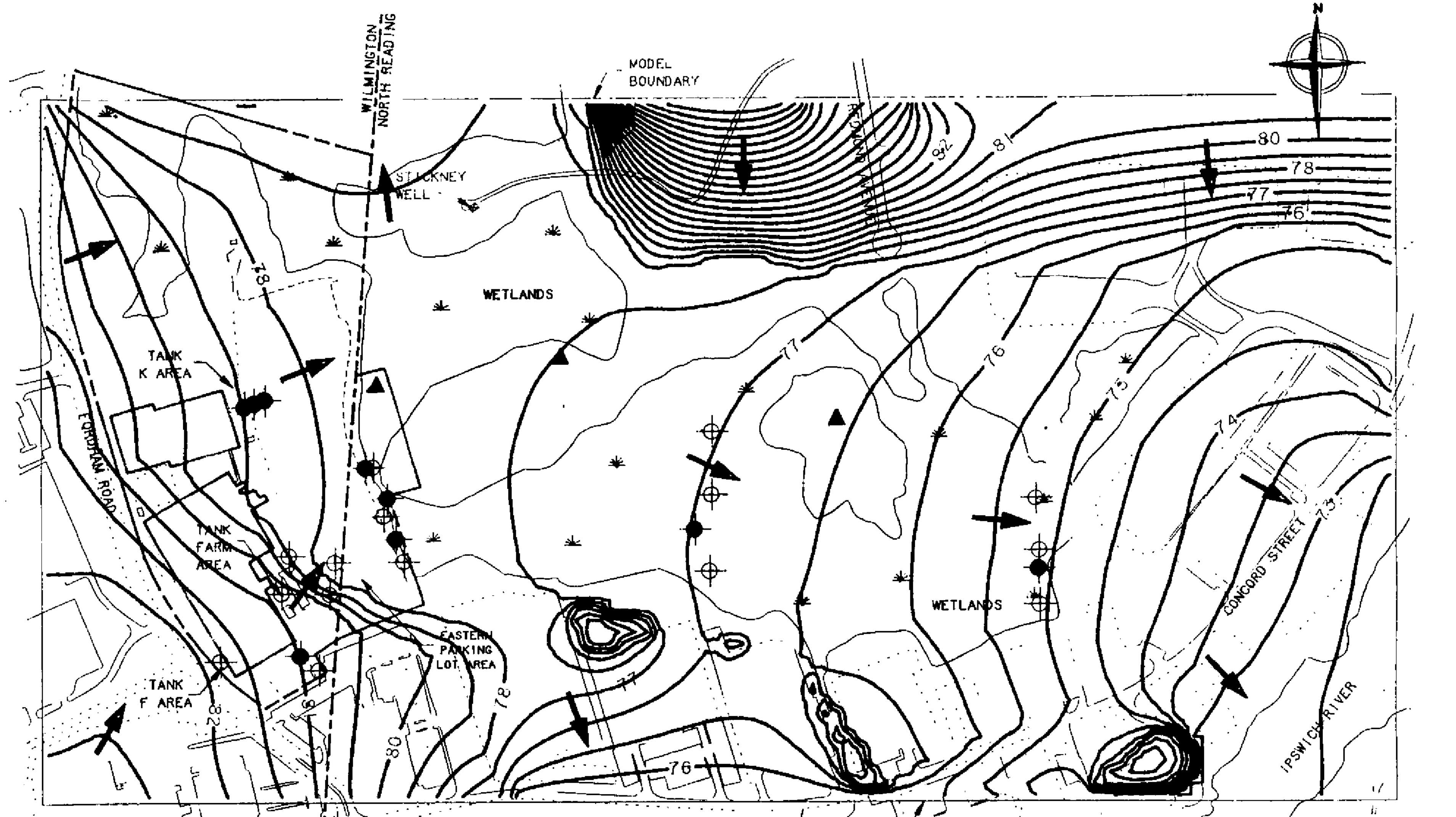
1. Simulation of non-pumping conditions (Figure 4-4) to estimate cleanup times of dissolved VOC contaminants by natural flushing.

2. Simulation of on-property recovery wells only, as shown in Figure 4-5. This component (Component 2) is designed to capture all contaminated groundwater on-property (Figure 4-6) which exceeds the cleanup objectives. To assure this capture, this component includes a total of seven overburden and nine bedrock recovery wells (with discharge of treated groundwater at five points in the wetlands).

   This component includes three recovery wells located in the shallow overburden materials of the Tank K Area with each well pumping at 5 gallons per minute (gpm). Three wells are screened in the deep overburden materials along the eastern property boundary directly downgradient of the Eastern Parking Lot Area and are pumping at a cumulative rate of 30 gpm. One shallow overburden well is installed near the southern portion of the property and is pumping at 2 gpm. Three bedrock wells are located along the eastern property boundary adjacent to the Eastern Parking Lot Area. Four bedrock wells are installed in the highly contaminated source areas of the Tank Farm and Eastern Parking Lot Areas. One well is screened in the upper bedrock zone in the Tank F Area and an additional bedrock well is located in the extreme southern portion of the property. Each bedrock well is pumping at approximately 1.75 gpm. The total pumping rate for all recovery wells is approximately 63 gpm or 90,000 gallons per day (gpd).

   Treated groundwater is discharged as surface water at two general locations in the wetlands. The northernmost discharge location shown on Figure 4-5 is releasing approximately 43 gpm of treated groundwater. The balance of 20 gpm is distributed amongst the four discharge points located approximately 200 feet east of the recovery wells along the eastern property boundary. This spacing and distribution of discharge points reduces drawdown of more than 0.5 feet to approximately 15,000 square feet of the wetlands (Figure 4-7).

3. Simulation of a hydraulic containment system consisting of the on-property wells outlined in component 2 combined with one overburden and three bedrock recovery



LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- ▲ SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION
- SIMULATED BEDROCK RECOVERY WELL LOCATION
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION
- —77— POTENTIOMETRIC CONTOUR-MODEL CALIBRATED TO ELEVATIONS MEASURED IN APRIL, 1993. CONTOUR INTERVAL = 0.5 FOOT. DATUM IS SEA LEVEL.
- GENERALIZED DIRECTION OF GROUNDWATER FLOW

0 500

SCALE, IN FEET

FIGURE 4-4

COMPONENT 1, POTENTIOMETRIC SURFACE SIMULATED WITH MODFLOW

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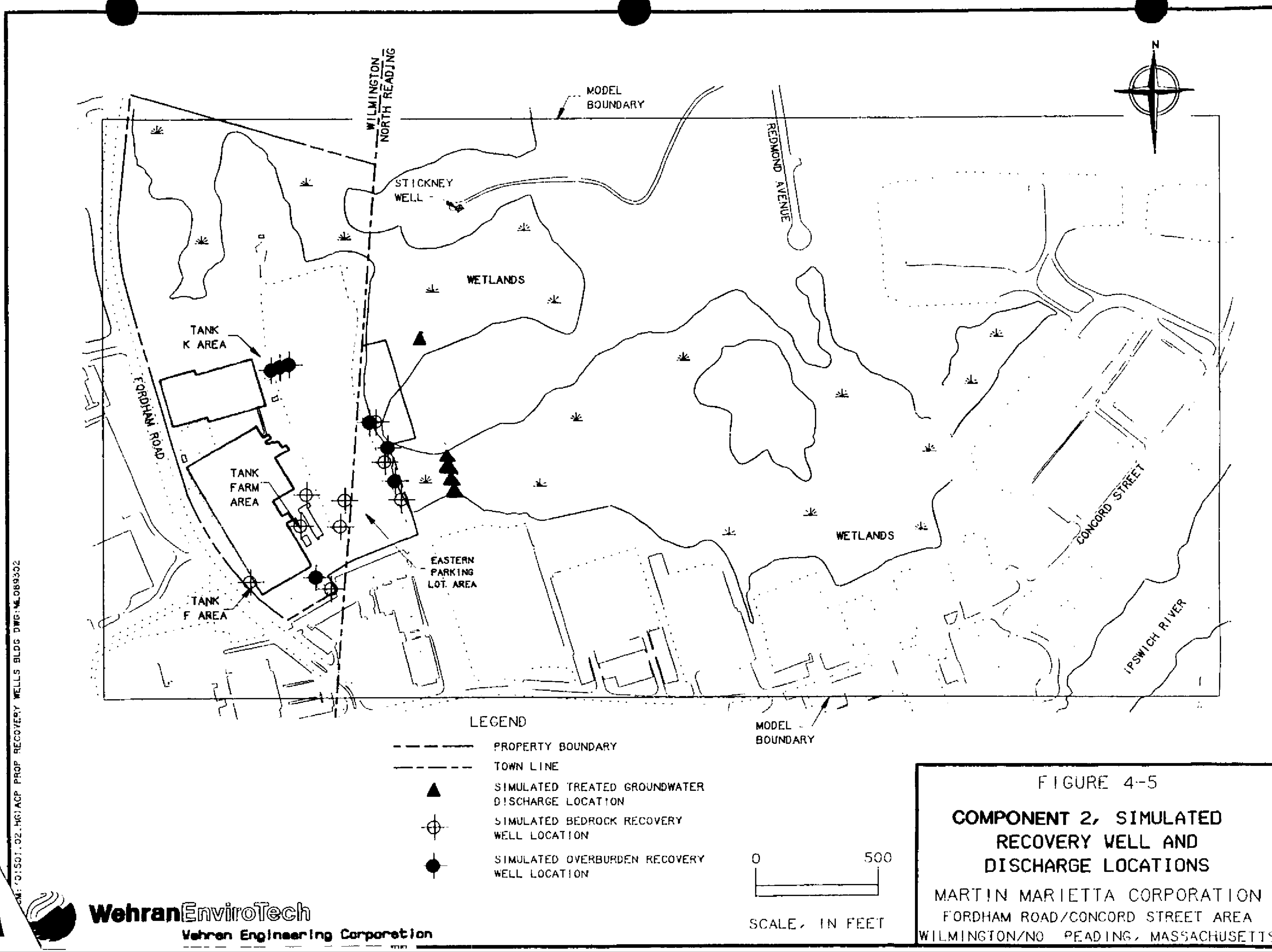

FIGURE 4-5

COMPONENT 2, SIMULATED RECOVERY WELL AND DISCHARGE LOCATIONS

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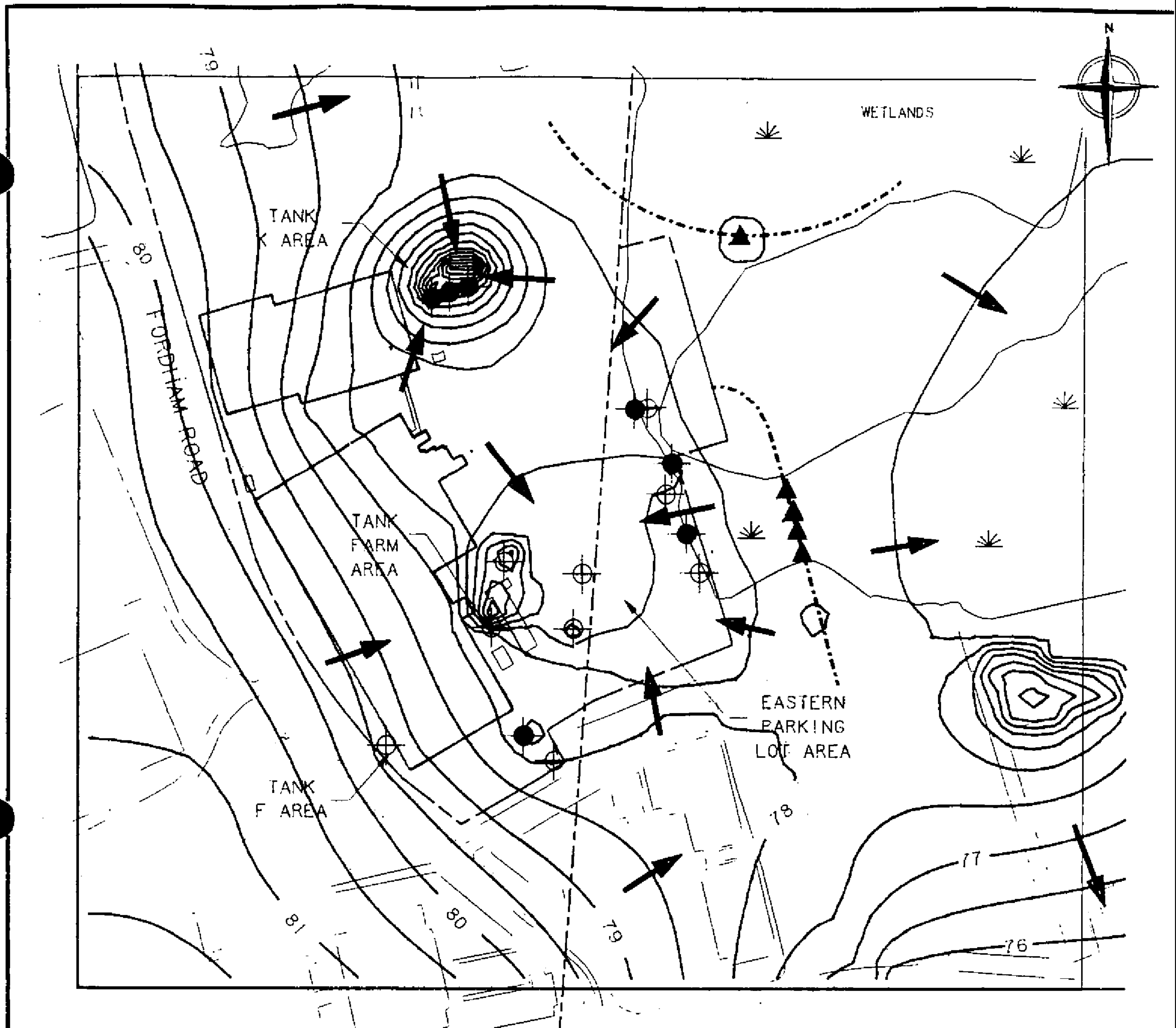
WILMINGTON/NO READING, MASSACHUSETTS



LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION
- SIMULATED BEDROCK RECOVERY WELL LOCATION
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION
- 77 — POTENTIOMETRIC CONTOUR - Model calibrated to shallow overburden aquifer elevations measured in April, 1993. Contour interval = 0.5 feet. Datum is sea level
- GENERALIZED DIRECTION OF GROUNDWATER FLOW
- APPROXIMATE LINE OF STAGNATION

0 300

SCALE, IN FEET

FIGURE 4-6

COMPONENT 2, POTENTIOMETRIC SURFACE SIMULATED WITH MODFLOW

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WILMINGTON/NO. READING, MASSACHUSETTS

09/24 OCM: 01501.02.HG1ACP MODFLOW POT SURFACE TWO DWG: ML099312

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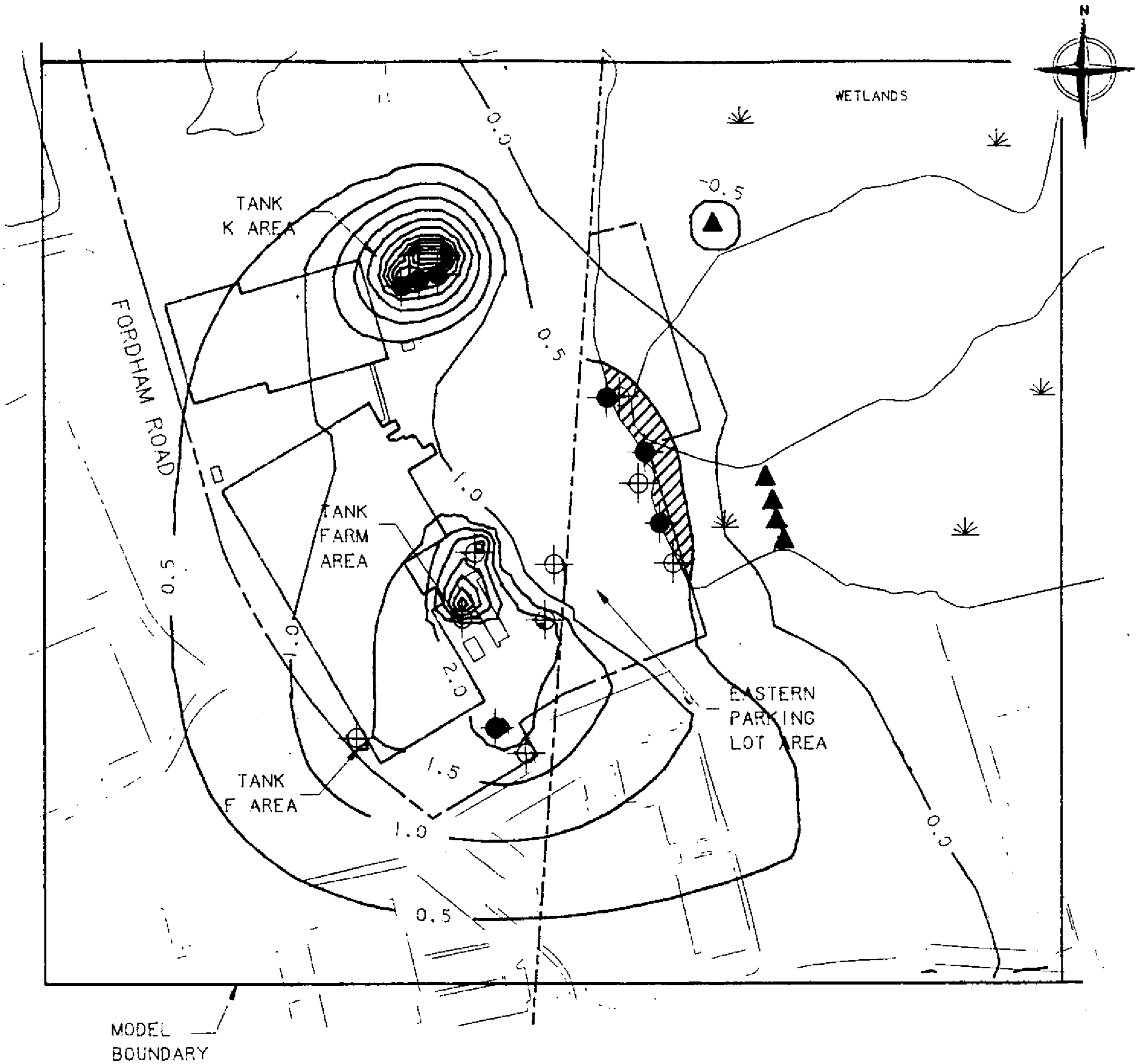

LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION
- SIMULATED BEDROCK RECOVERY WELL LOCATION
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION
- 1.0 LINE OF EQUAL DRAWDOWN, CONTOUR INTERVAL = 0.5 FEET
- AREA OF WETLANDS IMPACTED BY GREATER THAN 0.5 FOOT OF DRAWDOWN

0 300
SCALE, IN FEET

FIGURE 4-7

COMPONENT 2, LINE OF EQUAL DRAWDOWN SIMULATED WITH MODFLOW

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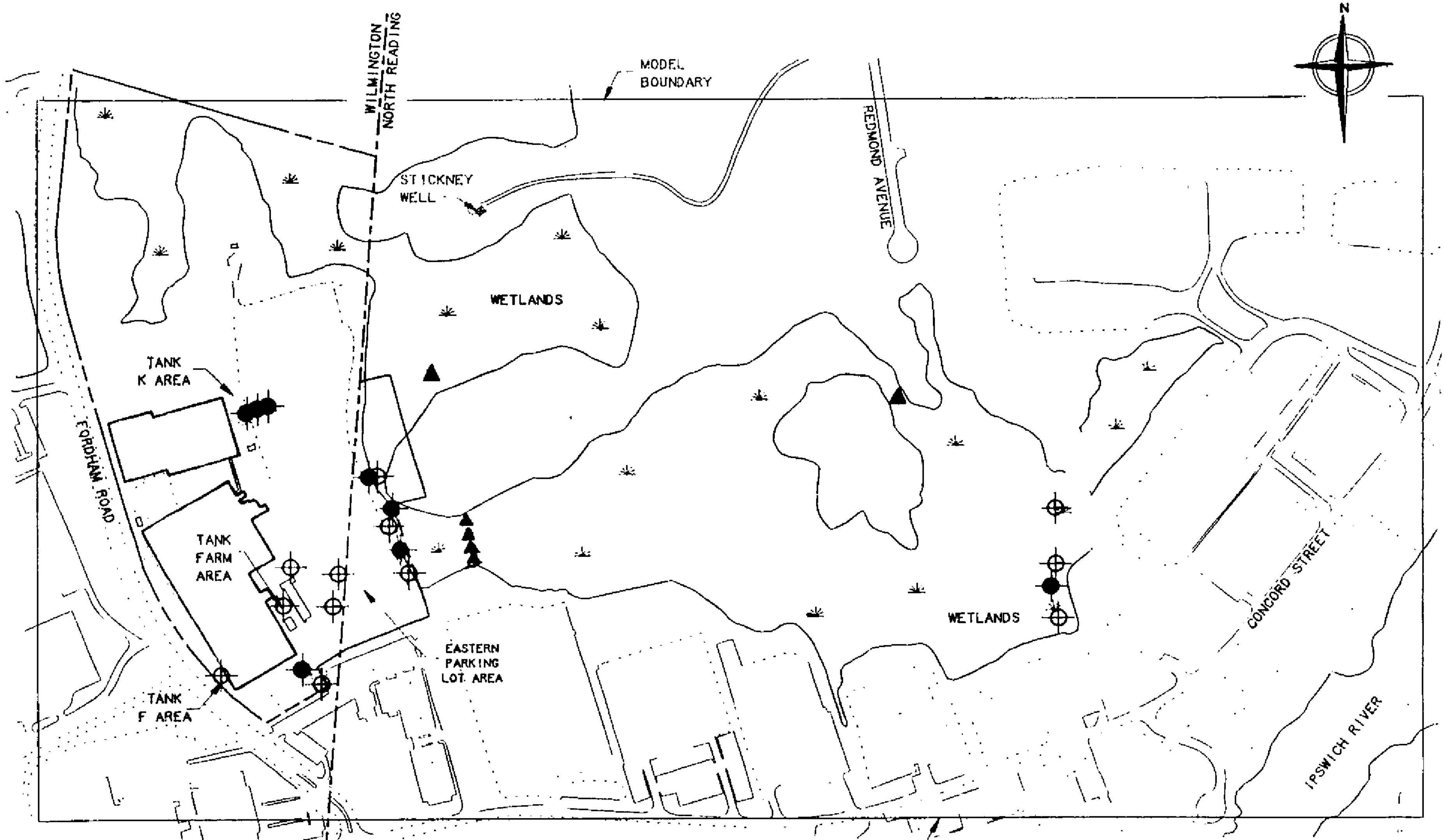
wells at the eastern end of the wetlands (see Figure 4-8). This component (Component 3) is designed to capture on-property contaminated groundwater as described for Component 2, and contaminated groundwater which exceeds cleanup objectives at the eastern end of the wetlands (Figure 4-9). These additional wells are located approximately 2,100 feet downgradient of the property. The single overburden wetlands well is screened in the deep overburden sand and gravel deposits and is pumping at a rate of 75 gpm. Each bedrock well is spaced approximately 225 feet apart and pumping at 5 gpm. The discharge of treated groundwater to the wetlands for the on-property wells is identical to the option outlined in component 2. The point of discharge for treated groundwater from the four wetland wells (90 gpm) is located approximately 500 feet upgradient of these recovery wells. This spacing and distribution of surface water discharge reduces drawdown of more than 0.5 feet in the wetlands to approximately 3.5 acres (Figure 4-10).

4. Simulation of a hydraulic containment system consisting of the same recovery wells outlined in Component 3 with an additional overburden and three bedrock recovery wells located in the middle of the wetlands, as shown in Figure 4-11. This component (Component 4) is designed to capture contaminated groundwater on-property and at multiple locations in the wetlands (Figure 4-12) to accelerate cleanup times.

   The additional wetlands overburden well is located approximately 1,000 feet downgradient of the property, is screened in the deep overburden materials and is pumping at a rate of 75 gpm. The three additional bedrock wetland wells are located approximately 1,100 feet downgradient of the property, are spaced approximately 225 feet apart and are pumping at 5 gpm each. The treated groundwater is discharged at 3 locations which reduces drawdown of more than 0.5 feet in the wetlands to approximately 19 acres. (see Figure 4-13)



LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- ▲ SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION
- SIMULATED BEDROCK RECOVERY WELL LOCATION
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION

0 500

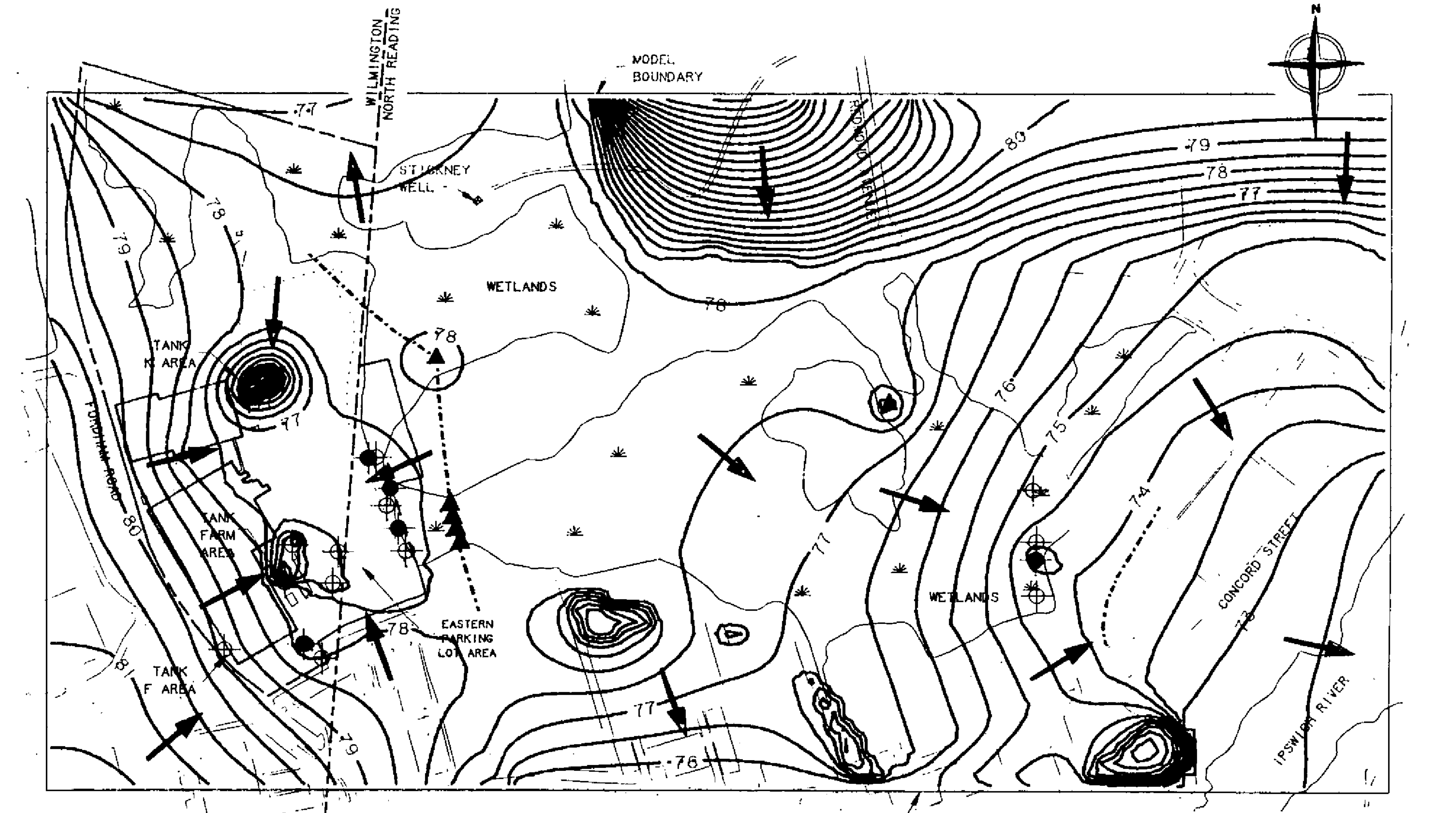
SCALE, IN FEET

FIGURE 4-8

COMPONENT 3, SIMULATED RECOVERY WELL AND DISCHARGE LOCATIONS

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

WehranEnviroTech
Wehran Engineering Corporation



LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION
- SIMULATED BEDROCK RECOVERY WELL LOCATION
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION
- 77 — POTENTIOMETRIC CONTOUR--MODEL CALIBRATED TO ELEVATIONS MEASURED IN APRIL, 1993. CONTOUR INTERVAL = 0.5 FOOT. DATUM IS SEA LEVEL.
- GENERALIZED DIRECTION OF GROUNDWATER FLOW
- APPROXIMATE LINE OF STAGNATION

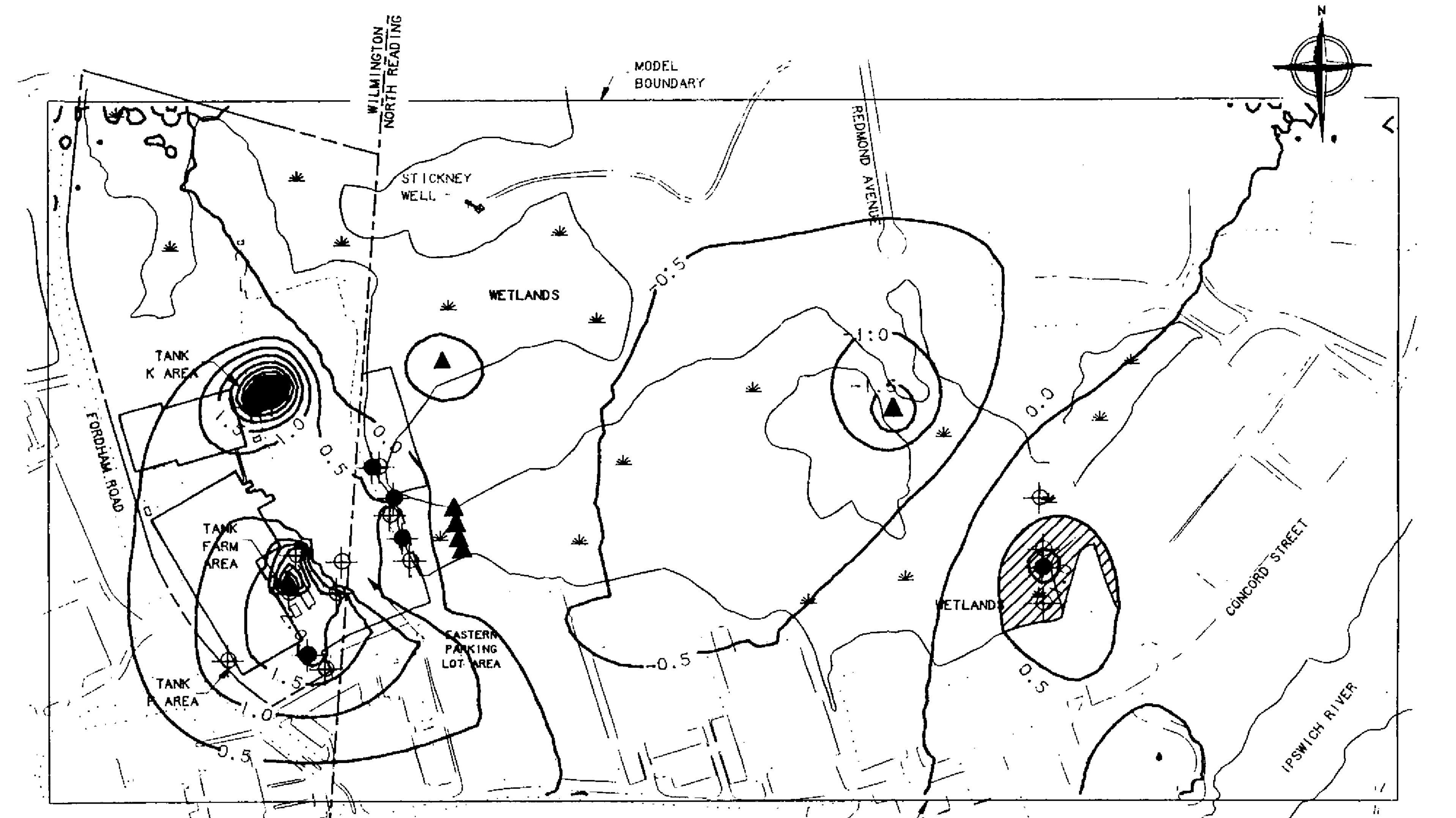
0 500
SCALE, IN FEET

FIGURE 4-9

COMPONENT 3, POTENTIOMETRIC SURFACE SIMULATED WITH MODFLOW

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

WehranEnviroTech
Wehran Engineering Corporation



LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION
- SIMULATED BEDROCK RECOVERY WELL LOCATION
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION
- 0.5 — LINE OF EQUAL DRAWDOWN, CONTOUR INTERVAL = 0.5 FOOT.
- AREA OF WETLANDS IMPACTED BY GREATER THAN 0.5 FOOT OF DRAWDOWN

0 500
SCALE, IN FEET

WehranEnviroTech
Wehran Engineering Corporation

FIGURE 4-10
COMPONENT 3, LINES OF EQUAL DRAWDOWN SIMULATED WITH MODFLOW

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO READING, MASSACHUSETTS

0/94 DCM:01501.02.HG)ACP ALT3 DRAWDOWN DWG:PS09935I

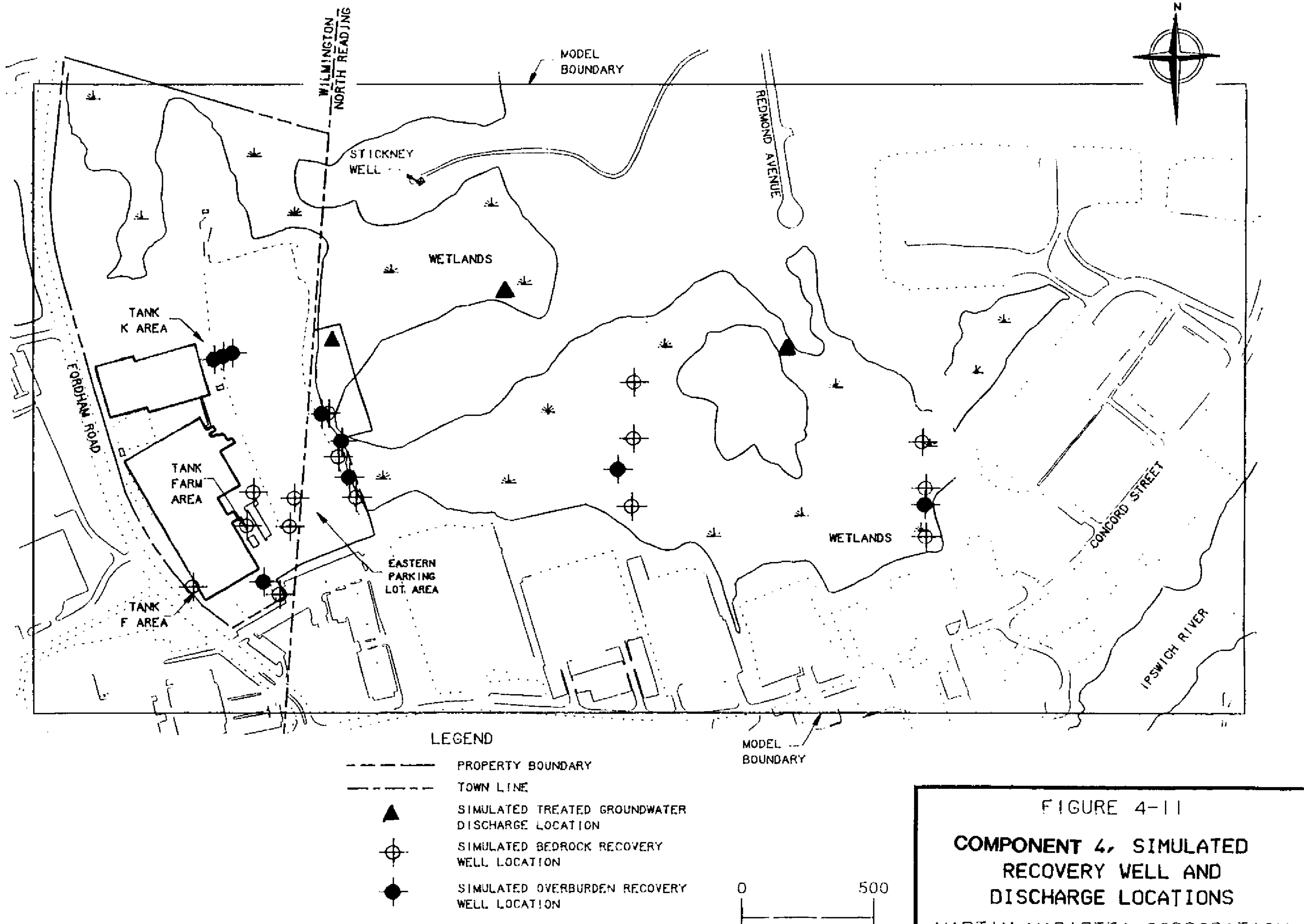


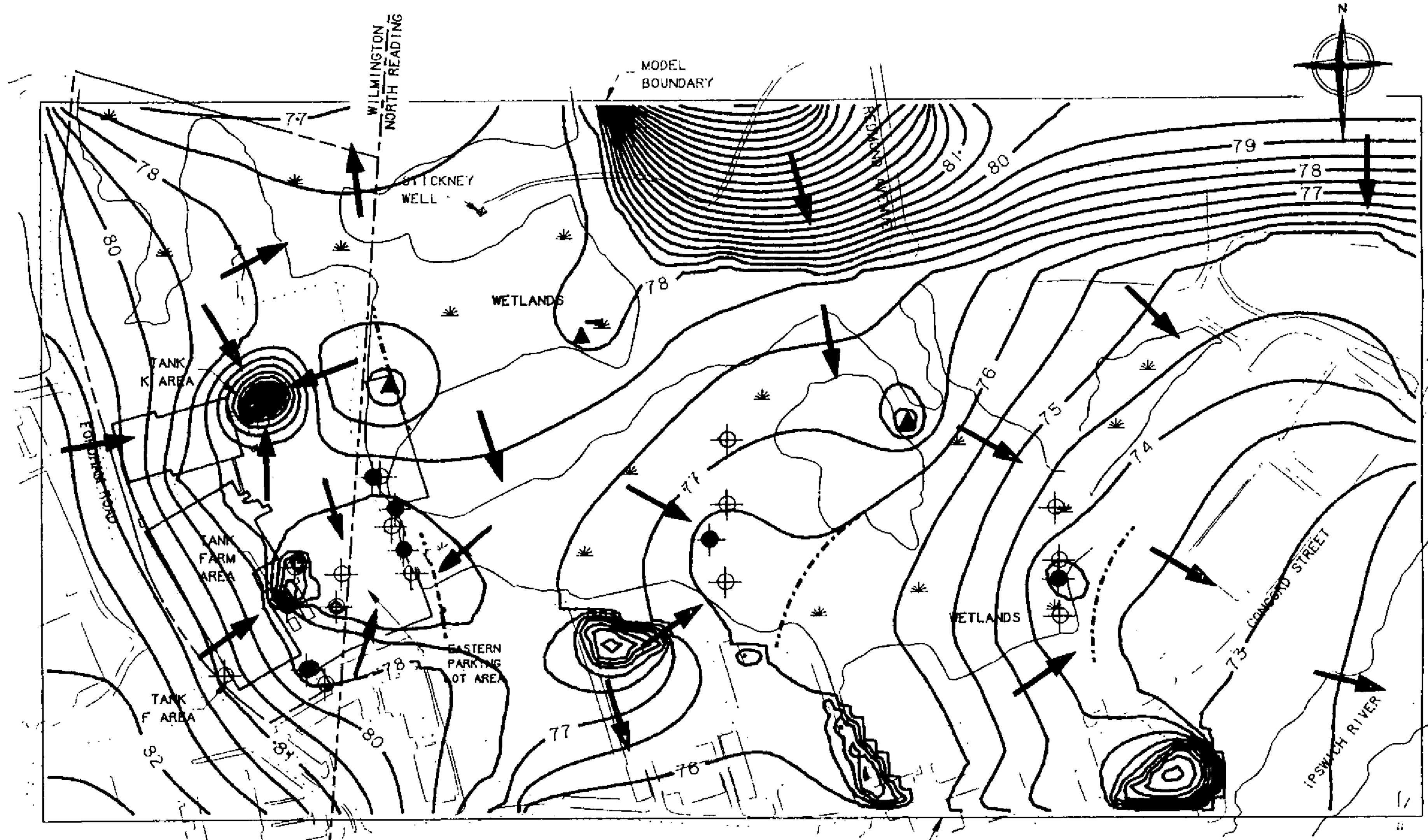
FIGURE 4-11

COMPONENT 4, SIMULATED RECOVERY WELL AND DISCHARGE LOCATIONS

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO READING, MASSACHUSETTS

WehranEnviroTech
Wehran Engineering Corporation

09/24 OCM-'O1501.02.HG\ACP ALT-4 PROP RECOVERY WELL DWG:ML099308



LEGEND

— — - —	PROPERTY BOUNDARY	——77——	POTENTIOMETRIC CONTOUR-MODEL CALIBRATED TO ELEVATIONS MEASURED IN APRIL, 1993. CONTOUR INTERVAL = 0.5 FOOT. DATUM IS SEA LEVEL.
— — — —	TOWN LINE		
▲	SIMULATED TREATED GROUNDWATER DISCHARGE LOCATION	◀——	GENERALIZED DIRECTION OF GROUNDWATER FLOW
⊕	SIMULATED BEDROCK RECOVERY WELL LOCATION	-·-·-·-	APPROXIMATE LINE OF STAGNATION
●	SIMULATED OVERBURDEN RECOVERY WELL LOCATION		

0 500

SCALE, IN FEET

FIGURE 4-12

COMPONENT 4,
POTENTIOMETRIC SURFACE
SIMULATED WITH MODFLOW

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

WehranEnviroTech
Wehran Engineering Corporation

C/04 DCM: Q1501.02.5G:ACP ALT 4 POT SURFACE DWG:PS099350

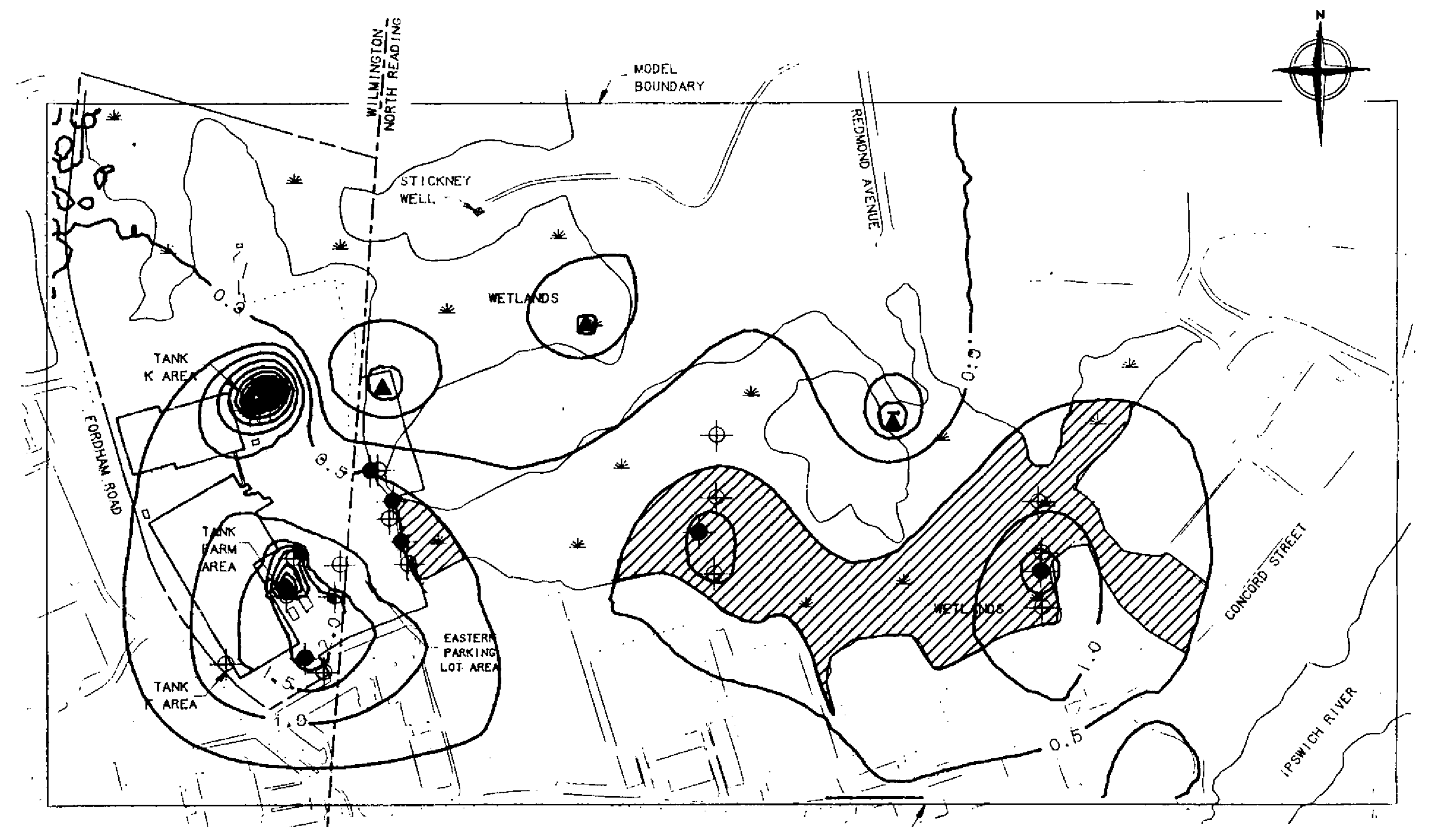


FIGURE 4-13

COMPONENT 4,
LINES OF EQUAL DRAWDOWN
SIMULATED WITH MODFLOW

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

WehranEnviroTech
Wehran Engineering Corporation

9/27 DCM:\01501.02\MG1ACP ALT 4 DRAWDOWN DWG:PS099349

4.5.1.6 Model Results

Component 1

Component 1 simulated no pumping. Under this component, the restoration of the aquifers in the modeled area depends upon natural flushing and other attenuation mechanisms. Under steady-state non-pumping conditions, the average travel time of a groundwater particle released from the Tank Farm Area takes approximately 16 to 18 years to reach the Concord Street/Ipswich River area in the southeastern corner of the modeled area (see Figure 4-2). Using the batch flush model, the estimated cleanup time for dissolved VOCs by natural flushing processes is approximately 500 years for overburden materials and much greater than 550 years for bedrock (see Table 4-9, Component 1).

Component 2

Component 2 simulated on-property recovery wells only, consisting of seven overburden and nine bedrock pumping wells, as shown in Figure 4-5. The resulting potentiometric surface and drawdown distribution are shown in Figures 4-6 and 4-7, respectively. The potentiometric surface and drawdown distribution resulting from the Tank K Area recovery system is shown in Figures 4-14 and 4-15, respectively.

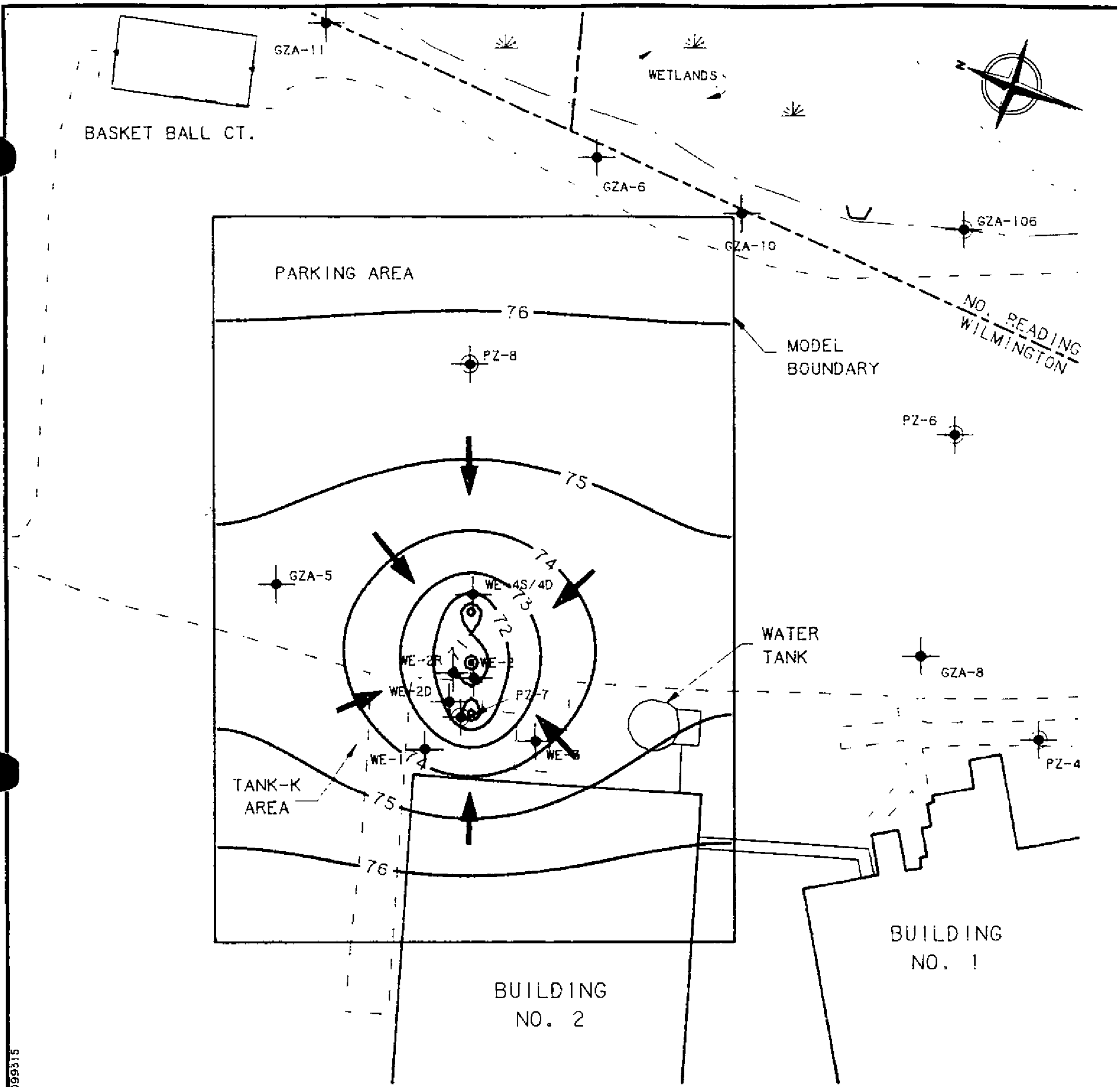
The results show that the simulated recovery wells will capture all of the contaminated water discharging from the property that would have migrated into off-property areas. Two major capture zones are created by the on-property recovery system, the smaller of the two created by the three shallow overburden wells at the Tank K Area, and the larger one created by the system of thirteen recovery wells (four overburden and nine bedrock) installed in the Tank F, Tank Farm, and Eastern Park Lot Areas. The maximum extent of the larger capture zone is approximately 800 feet wide, 1,000 feet long and 100 feet deep. The boundary of this larger zone extends approximately 200 feet south of the southern property boundary, upgradient of Fordham Road along the western and southwestern property boundaries, along the northern portion of Building 1 across the parking lot to monitoring well GZA-10, and 300 feet east of the eastern property boundary to the downgradient point of stagnation created in the wetlands. The maximum vertical extent of this capture zone includes those areas screened in the deeper bedrock at a depth of 100 feet below ground surface.

Table 4-9

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF ESTIMATED CLEANUP TIMES*

Component	Contaminated Overburden	Aquifer Zone Bedrock	Maximum Cleanup Time (years)
Component 1			
• On-Property Areas Only	60	85	>>550
• Western Property Boundary	550	>>550	
Component 2			
• On-Property Areas Only	20	15	80
• Eastern Property Boundary to the Ipswich River	65	80	
Component 3			
• On-Property Areas Only	20	15	
• Eastern Property Boundary to Eastern End of Wetlands	55	65	65
• Eastern End of Wetlands to the Ipswich River	10	15	
Component 4			
• On-Property Areas Only	20	15	
• Eastern Property Boundary to Middle of Wetlands	20	35	35
• Middle of Wetlands to Eastern End of Wetlands	20	30	
• Eastern End of Wetlands to the Ipswich River	10	15	

* Cleanup times estimated using the batch flush model



LEGEND

PROPERTY BOUNDARY

TOWN LINE

SIMULATED OVERBURDEN RECOVERY WELL LOCATION

77 — POTENTIOMETRIC CONTOUR - Model calibrated to shallow overburden aquifer elevations measured in April, 1993. Contour interval = 0.5 feet. Datum is sea level

GENERALIZED DIRECTION OF GROUNDWATER FLOW

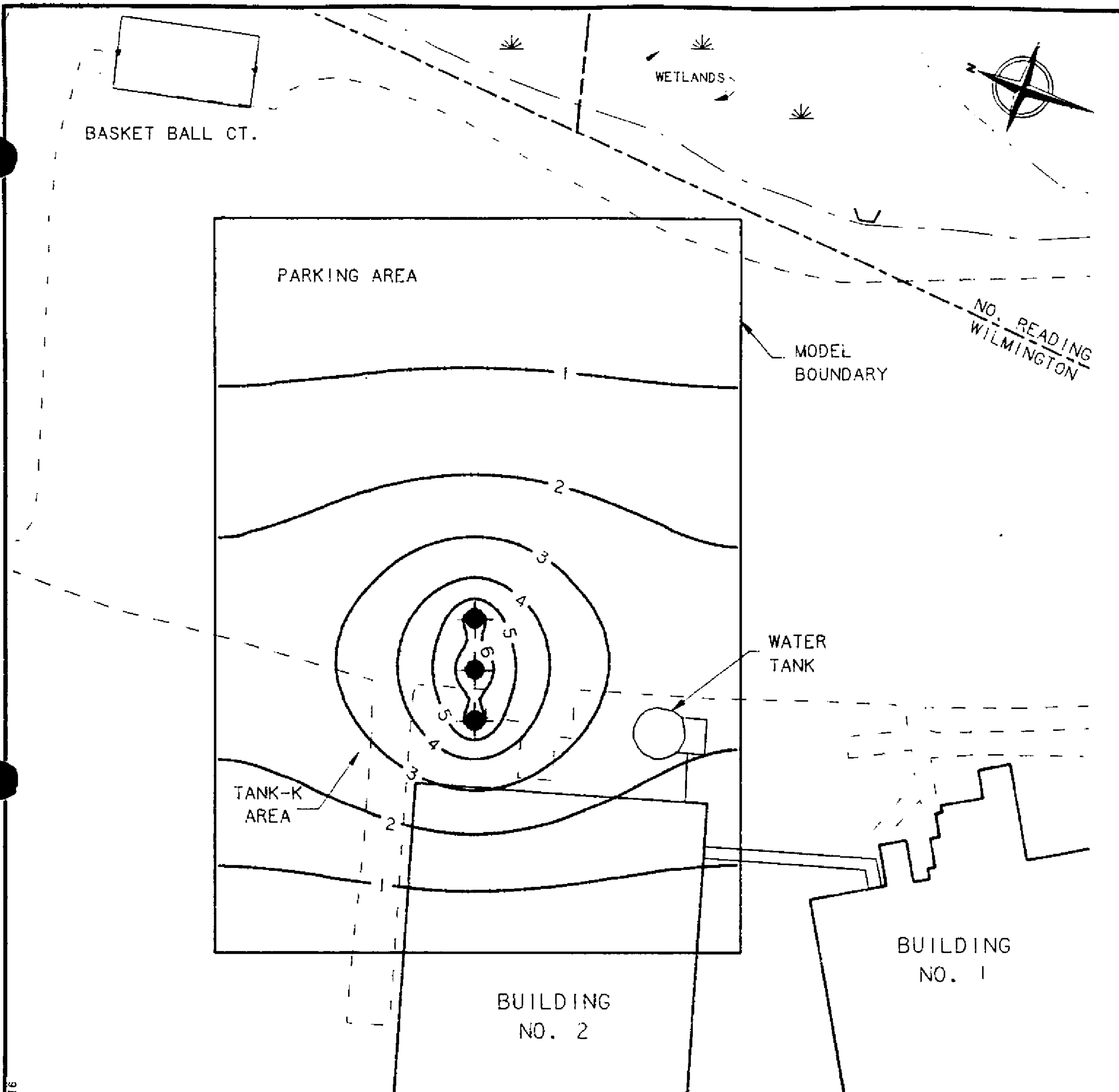
FIGURE 4-14

TANK-K AREA, POTENTIOMETRIC SURFACE SIMULATED WITH MODFLOW

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

WehranEnviroTech
Wehran Engineering Corporation

WEHRAN PROJECT NO. 01501.0



LEGEND

- PROPERTY BOUNDARY
- TOWN LINE
- SIMULATED OVERBURDEN RECOVERY WELL LOCATION
- 1.0 — LINE OF EQUAL DRAWDOWN, CONTOUR INTERVAL = 1.0 FEET

0 100

SCALE, IN FEET

FIGURE 4-15

TANK-K AREA, LINES OF EQUAL DRAWDOWN SIMULATED WITH MODFLOW

MARTIN MARIETTA CORPORATION

FORDHAM ROAD/CONCORD STREET AREA

WILMINGTON/NO. READING, MASSACHUSETTS

WehranEnviroTech

Wehran Engineering Corporation

WEHRAN PROJECT NO. 01501.0

09/24 OCM: 01501. ...31ACP MODFLOW TANK-K DRAWDOWN DWG: WL099316

The smaller capture zone associated with the Tank K Area is approximately 300 feet wide and 400 feet long (see Figure 4-14). The drawdown distribution shown in Figure 4-15 illustrates the large cone of depression created by the three recovery wells.

Figures 4-4 and 4-6 show that the northernmost surface water discharge point shifted the pre-existing groundwater divide near the Stickney well to an area approximately 500 south. Figure 4-7 and Table 4-10 show that the discharge of treated water to the wetlands reduced the area of wetlands impacted by dewatering (greater than 0.5 feet of drawdown) to less than approximately 15,000 square feet (ft^2).

Under Component 2, the estimated cleanup times for overburden deposits and bedrock in the on-property area are approximately 20 and 15 years, respectively (see Table 4-9, Component 2). These estimates are based on an average travel time of 2 years for groundwater particles released inside the source areas to reach a recovery well and an estimated 10 pore volumes of clean water required to flush VOCs from the contaminated zones.

The on-property recovery system created a hydraulic barrier which effectively cutoff further migration of contaminated groundwater to the wetlands. Results of the particle tracking model suggested an average travel time of approximately 7 years for groundwater particles released downgradient of the point of stagnation created by the on-property recovery system (near piezometer cluster PS-1) to reach the Ipswich River. A total of 9 pore volumes of clean water was estimated to flush the contaminated overburden aquifer zone from the point of stagnation; through the wetlands, to the Ipswich River. This gives an estimate of approximately 65 years for cleanup of this overburden zone. Applying the same technique to the bedrock yields a cleanup time of approximately 80 years (based on a 9 year travel time and 9 pore volumes).

Component 3 - on-property + eastern end of wetlands.

Under Component 3, the groundwater containment and surface water discharge options are identical to those outlined in Component 2, with the addition of one deep overburden well, three bedrock wells, and one surface water discharge point located at the eastern end of the wetlands, as shown in Figure 4-8. The results indicate complete capture of on-property groundwater as described under Component 2. The resulting potentiometric surface and the drawdown distribution for this component are shown in Figures 4-9 and

4-10, respectively. A zone of influence is created at the far end of the wetlands which effectively recovers groundwater within a 500 foot wide capture zone that extends to 120 feet below ground surface into the fractured bedrock aquifer. These recovery wells prevent further migration of contaminated groundwater emanating from the wetlands to Concord Street and the Ipswich River in the southeastern portion of the modeled area.

Under this component, the extent of wetlands impacted by dewatering due to pumpage is much larger. Table 4-10 and Figure 4-10 shows that approximately 150,000 ft^2 (3.5 acres) of wetlands was estimated to be impacted by greater than 0.5 feet of drawdown.

Under this component, the estimated cleanup times for the on-property groundwater remains the same at approximately 20 and 15 years in the overburden and bedrock, respectively (see Table 4-9, Component 3). Contaminants are flushed out of the contaminated zone between the eastern property boundary and the recovery wells at the endpoint of the wetlands in approximately 55 and 65 years for the overburden and bedrock aquifers, respectively. The estimated time for VOCs to achieve cleanup objectives in the zone between the downgradient stagnation point of the recovery wells at the eastern end of the wetlands and the Ipswich River is approximately 10 years for the overburden and 15 years for bedrock.

Component 4 - on-property, eastern portion + middle of wetlands.

Component 4 simulated the placement of recovery wells in identical fashion to those shown in Component 3 with the addition of one deep overburden well and three bedrock wells near the middle of the wetlands (see Figure 4-11). The results indicate complete capture of on-property groundwater as described under Component 2. As described in Component 3, a zone of influence is created at the eastern end of the wetlands which prevents further migration of contaminated groundwater emanating from the wetlands to the Concord Street/Ipswich River area. The placement of an additional deep overburden recovery near the midpoint of the wetlands creates a zone of influence which effectively recovers groundwater within a 600 foot wide capture zone that extends to 60 feet below ground surface to the bottom of the aquifer. The three additional bedrock wells create a capture zone which extends across the bedrock valley and is approximately 750 feet wide.

Under this component, the extent of wetlands impacted by dewatering due to pumpage is much larger. Table 4-10 and Figure 4-13 shows that approximately 830,000

Table 4-10

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SUMMARY OF WETLANDS AREA IMPACTED BY DEWATERING

Groundwater Collection Component	Pumping Locations	Treated Groundwater Discharge Location	Drawdown greater than 0.5 feet
1	None	None	0 ft^2
2	On-Property Only	On-Property and Off-Property Wetlands	15,000 ft^2
3	On-Property and Eastern End of Wetlands	On-Property and Off-Property Wetlands	150,000 ft^2
4	On-Property and Middle and Eastern End of Wetlands	On-Property and Off-Property Wetlands	830,000 ft^2

Total Area of Wetlands ~75 acres

square feet (19 acres) of wetlands is estimated to be impacted by greater than 0.5 feet of drawdown. The cleanup time for any one of the different contaminated zones within the modeled area does not exceed approximately 20 years for overburden materials and approximately 35 years for bedrock (see Table 4-9, Component 4).

4.6 CHARACTERIZATION OF GROUNDWATER

To design appropriate treatment systems, anticipated contaminant concentrations must be determined for three potential areas of groundwater recovery: Tank K Area, Tank Farm/Eastern Parking Lot Area, and the wetlands. The following discussion summarizes the levels of contaminants detected in each of these three areas.

In the Tank K area, groundwater is contaminated with gasoline as characterized by BTEX compounds. Table 4-11 indicates the average concentration of BTEX compounds in the groundwater. These concentrations are indicative of groundwater saturated with weathered gasoline. Also in this area, a thin layer of separate phase product has been detected in some sampling rounds. For the purposes of this FS, the average concentration of BTEX compounds in wells PZ-7S, WE-4S and WE-2 will be used as the design concentrations for groundwater pumped from the Tank K Area.

For the Tank Farm/Eastern Parking Lot Area, groundwater data was assigned to each of the proposed recovery wells (Section 4.5.2) based on data from the nearest existing well. A flow weighted average was calculated as the design concentration for this area. Table 4-12 lists the proposed recovery wells, the nearest existing wells, proposed flow rate, and concentrations detected in the existing well. The major compounds of primary concern in this collection area are: 1,2 dichloroethene (485 μg/l), tetrachloroethene (490 μg/l), trichloroethene (560 μg/l), and vinyl chloride (160 μg/l). Separate phase Stoddard solvent has also been detected in this area.

The influent to a treatment system receiving contaminated groundwater from on-property wells only would have a combined flow of 65 gpm (Tank K area 15 gpm and Tank Farm/Eastern Parking Lot approximately 50 gpm) and combined contaminant concentrations as indicated in Table 4-13.

For groundwater beneath the wetlands, the average data from the January 1993 quarterly sampling is indicated in Table 4-14. The reason for using this data is that no sampling of groundwater in the wetlands was conducted as part of the Phase II Second

Table 4-11

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF TANK K GROUNDWATER QUALITY

Well I.D.	Average Concentrations (mg/l)*				
	Benzene	Toluene	Ethylbenzene	Total Xylenes	Iron**
PZ-7S	ND	17.2	2.4	16.9	
WE-2	1.3	20.3	1.5	21.5	
WE-4S	4.9	8.5	1.8	13.0	
Average	2.1	15.3	1.9	17.1	190**

Notes:
* Average concentrations of data summarized in Phase II Second Supplemental Investigation (Wehran).
** Average concentrations of data summarized in Phase II Supplemental Investigation (Wehran, November 1991).
ND Not Detected.

Table 4-12

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF TANK FARM/EASTERN PARKING LOT GROUNDWATER QUALITY

Proposed Well ID	Nearby Existing Well ID	Flow Rate	Average Concentrations (µg/l)*												
			Acetone	1,1-DCA	1,1 DCE	1,2 DCE	Methylene Chloride	PCE	1,1,1 TCA	TCE	Toluene	Total Xylene	Vinyl Chloride	Bromo-methane	Iron**
OB-1	GZA-106D	10.0	-	-	-	1.7	-	45	-	38.3	-	-	-	-	
OB-2	GZA-9	12.0	3.3	0.4	-	49	1.7	59.3	-	69.7	-	-	-	-	
OB-3	GZA-107D	8.0	-	1.9	1.4	4.9	-	24.5	0.8	37	-	-	-	-	
OB-4	PZ-1D	2.0	5	11	2.8	3.1	2.5	2.5	3.8	49	-	-	-	-	
BR-1	GZA-106R	1.5	-	0.7	-	11.0	-	35	-	105	-	-	-	-	
BR-2	GZA-9	2.0	3.3	0.4	-	49	1.7	59.3	-	69.7	-	-	-	0.9	
BR-3	GZA-107R	2.0	24	0.6	-	1	-	3.1	-	16.5	4.4	-	-	-	
BR-4	PZ-1R	0.25	-	1.8	11.8	0.8	1.7	2.1	19.8	74	-	-	-	-	
BR-5	GZA-101R	1.5	22.7	15	-	11.5	-	590.3	-	1252	11.2	-	-	-	
BR-6	GZA-103R2	1.0	-	31.3	1.6	5568	6.3	162.5	-	380	1273.5	19.3	2982.5	-	
BR-7	GZA-102R2	1.0	-	35.3	13	600	1.7	1170	3.4	3533.3	0.6	0.6	48	-	
BR-8	GZA-105R	2.5	9	163.7	36	333	7.7	3193.3	-	6300	-	-	6.3	-	
BR-9	WE-5R	2.0	-	78	-	1700	25	960	-	960	29	18	1800	-	

Table 4-12

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
SUMMARY OF TANK FARM/EASTERN PARKING LOT GROUNDWATER QUALITY

Proposed Well ID	Nearby Existing Well ID	Flow Rate	Average Concentrations (μg/l)*												
			Acetone	1,1-DCA	1,1 DCE	1,2 DCE	Methylene Chloride	PCE	1,1,1 TCA	TCE	Toluene	Total Xylene	Vinyl Chloride	Bromo-methane	Iron**
BR-10	PZ-4R	1.0	-	2.4	-	18.5	-	225	-	255	-	-	-	-	
TF-1	GZA-103R1	0.8	-	18.8	18.2	14,820	1007	11,634	8.2	1156	4916	28	1260	340	
Total		47.55	3.4	15.1	2.9	484.9	19.2	487.8	0.6	559.5	110.4	1.6	160	5.8	40**
Groundwater Standards (GW-1)			3000	70	7	70	5	5	200	5	1000	10,000	2	2	0.3

Notes:
* Average concentrations of data summarized in the Phase II Second Supplemental Investigation.
** Average concentration of data summarized in the Phase II Supplemental Investigation (mg/l).

- = Not Detected
1,1 DCA = 1,1 Dichloroethane
1,1 DCE = 1,1 Dichloroethene
1,2 DCE = c-1,2-Dichloroethene
PCE = Tetrachloroethene
1,1,1 TCA = 1,1,1 Trichloroethane
TCE = Trichloroethene

Table 4-13

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
ESTIMATED ON-PROPERTY GROUNDWATER QUALITY

Collection Area	Flow (gpm)	Concentrations = mg/l										
		Iron	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Methylene Chloride	1,2 DCE	Bromo-methane	PCE	TCE	Vinyl Chloride
Tank K*	15	190	2.1	15.3	1.9	17.1	-	-	-	-	-	-
Tank Farm/ Eastern Parking Lot**	50	40	-	0.1	-	-	0.020	0.485	.006	0.490	0.560	0.160
Flow Weighted Average	65	75	0.550	3.600	0.450	3.95	0.15	0.375	.005	0.375	0.430	0.125
Groundwater Standard (GW-1)		0.3	0.005	1.000	0.700	10.000	0.005	0.070	0.002	0.005	0.005	0.002

Notes:
* Average concentrations from Table 4-11.
** Average concentrations from Table 4-12.

Table 4-14

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
WETLANDS GROUNDWATER QUALITY

JAN 1993

date of samples [illegible]

Well ID	Concentration (μg/l)				
	1,2-DCE	PCE	TCE	Vinyl Chloride	Iron
PS-1D	24	87	240	-	
PS-1D (duplicate)	24	69	200	-	
PS-2D	11	50	160	-	
PS-5D	35	10	78	-	
Average	23.5	54.0	169.5	-	30*

Note:

* Average concentration of data summarized in Report on Contamination at Stickney Well (Camp, Dresser and McKee, November 1986).

PS-1S, -1M, -1D.
PS-2S, -2M, -2D.
PS-4
PS-5S, -5D.

Supplemental Investigation (1992). In general, the same primary compounds are present in the wetlands as in the Tank Farm/Eastern Parking Lot Area, with the exception of vinyl chloride. Stoddard solvent, however, has not been detected in groundwater in the wetlands.

For the evaluation of a treatment plant to handle flow from both proposed on-property recovery wells and the one set of recovery wells at the eastern end of the wetlands, the influent would have the properties presented in Table 4-15 (based on concentrations detected in wells in the wetlands and the estimated concentrations for on-property recovery wells in Table 4-13). For the combination of on-property recovery wells and two sets of wetland recovery wells, the treatment plant influent characteristics are presented in Table 4-16 based on similar assumptions as Table 4-15.

4.7 DEVELOPMENT OF GROUNDWATER TREATMENT COMPONENTS

Based on the modeling results presented in Section 4.5, the groundwater collection components include: 1) no pumping, 2) on-property recovery wells only with treated water discharged to wetlands, 3) on-property recovery wells and recovery wells at the eastern end of the wetlands with treated water discharged to multiple wetlands locations and, 4) on-property recovery wells and two sets of wetland recovery wells with treated water discharged to multiple wetland locations. These groundwater collection components form the major distinctions among the remedial action alternatives evaluated in Section 5.0. Under each of these components, an evaluation must be made concerning the treatment train which will be used to meet discharge limits. Also, under Components 3 and 4, a decision must be made regarding the need for one treatment plant which would be used to handle contaminated groundwater from both on-property wells and wetland wells or whether to have a separate treatment plant for each source of groundwater. At this point in the FS, in order to take advantage of economics of scale (i.e., less expensive to construct a 155 or 245 gpm treatment plant than a 65 gpm and 90 gpm or 65 gpm and 180 gpm treatment plants) and less maintenance associated with a single plant, the groundwater will be combined into a single treatment system for both components. A detailed discussion is presented below for the groundwater treatment components of each groundwater collection component.

Table 4-15

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER QUALITY - ON PROPERTY AND EASTERN END OF WETLANDS

Collection Area	Concentration (mg/l)											
	Flow (gpm)	Iron	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Methylene Chloride	1,2 DCE	Bromo-methane	PCE	TCE	Vinyl Chloride
On Property*	65	75	0.55	3.60	0.45	3.95	0.015	0.375	0.005	0.375	0.430	0.125
Wetlands**	90	30	-	-	-	-	-	0.025	-	0.055	0.170	-
Flow Weighted Average	155	50	0.250	1.500	0.200	1.650	0.005	0.200	0.002	0.200	0.300	0.050
Groundwater Standard (GW-1)		0.3	0.005	1.000	0.700	10,000	0.005	0.070	0.002	0.005	0.005	0.002

Notes:
* Average concentration from Table 4-13.
** Average concentration from Table 4-14.

Table 4-16

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

TOTAL SITE GROUNDWATER QUALITY - ON PROPERTY AND MIDDLE AND EASTERN END OF WETLANDS

Collection Area	Concentration (mg/l)											
	Flow (gpm)	Iron	Benzene	Toluene	Ethyl-benzene	Total Xylenes	Methylene Chloride	1,2 DCE	Bromo-methane	PCE	TCE	Vinyl Chloride
On Property*	65	75	0.550	3.600	0.450	3.950	0.015	0.375	0.005	0.375	0.430	0.125
Wetlands**	190	30	-	-	-	-	-	0.025	-	0.055	0.170	-
Flow Weighted Average	245	45	0.145	0.955	0.120	1.050	0.004	0.120	0.001	0.140	0.240	0.035
Groundwater Standard (GW-1)		0.3	0.005	1.000	0.700	10,000	0.005	0.070	0.002	0.005	0.005	0.002

Notes:
* Average concentration from Table 4-13.
** Average concentration from Table 4-14.

4.7.1 Component 1: No Action

No treatment is required under the no-action groundwater component. Groundwater monitoring would be performed for a period of 80 years.

4.7.2 Component 2: Treatment of On-Property Groundwater Only

This component involves treating on-property groundwater with the highest level of contamination, the on-property groundwater. Based on the cleanup times developed in Section 4.6.3, the treatment plant for this component would operate on-site for 20 years with groundwater monitoring for the entire aquifer for a period of 80 years.

The recovery system (Section 4.6.2) includes seven overburden wells (flow rates ranging from 2 - 12 gpm) and eleven bedrock wells (flow rates ranging from 0.25 - 2.5 gpm). The total flow rate is approximately 65 gpm with estimated characteristics as indicated in Table 4-13. The recovered groundwater will flow through approximately 3600 feet of piping (with secondary containment) to a treatment plant located in the northeast corner of the parking lot, away from facility operations. The exact location and configuration of this treatment building is dependent upon the treatment technology chosen and will be provided in the final construction plans for the treatment system.

Based on the data from the Phase II investigations, pretreatment for TPH, iron, and manganese will be required. For all of the proposed methods of VOC removal (air stripping, carbon adsorption, chemical oxidation) TPH should be limited to 10 ppm and iron plus manganese to 5 ppm. To conduct this pretreatment, the groundwater from the recovery wells will pass through an oil/water separator into a flow equalization tank. Separated product will be transferred to a storage tank for off-site disposal. The equalization tank will be provided to: 1) equilibrate groundwater flow from the recovery system and provide a near constant flow to downstream processes, and 2) provide a sink for residual flows (e.g., supernatant from sludge holding tank, filtrate from filter press, backwash from filters). The equalization tank will have a high level sensor which will shut down the well pumps when the tank is full, and a low level sensor which will shut down subsequent treatment processes when the equalization tank is empty. A transfer pump will provide a constant flow rate to the chemical precipitation process.

In the chemical precipitation process, lime will be added to the water to increase the pH of the water to 9 - 10 which will cause dissolved metals to be converted to an insoluble form and precipitate as metal hydroxides and carbonates. In addition to being less expensive than caustic, lime results in a reduction of total dissolved solids (i.e., calcium precipitates with the iron as a carbonate, while sodium remains in solution) and phosphorus. A polymer will be added in the flocculation tank to enhance agglomeration of precipitated particles. These flocs will be separated out in a clarifier or settling tank. The water will then flow into a neutralization tank and the sludge will be processed by thickening (sludge holding tank) and dewatering (filter press). Based on the 75 mg/l of iron and 200 mg/l of hardness $CaCO_3$ in the influent, the estimated quantity of sludge to be disposed of annually is 1000 ft^3. Neutralization with acid (e.g. sulfuric) of the groundwater following the precipitation process will be necessary to meet the surface water discharge limits for pH.

The water will then flow to the dual-media filters to remove any suspended solids that passed through the clarifier. This filtration system consists of a tank with an underdrain covered by a porous area, which supports the filter media (sand and anthracite). The filtration system will be equipped with an automatic backwash that will clean the filter media to prevent retained solids from blocking up the bed. The backwash will be directed back to the equalization tank. The preliminary design criteria for the lime precipitation system and associated processes (flow equalization, neutralization, filtration, sludge handling) are presented in Table 4-17.

The filtered water will be pumped from the filter clearwell to the VOC removal step. This step will consist of either air stripping, carbon adsorption or chemical oxidation. These treatment technologies are discussed below.

4.7.2.1 Component 2 with Air Stripper

Groundwater contaminated with BTEX and chlorinated volatile organics (Cl-VOC) will be pumped from the filter clearwell to a nozzle at the top of a packed tower. The contaminated water will be sprayed onto the packing material, while at the same time as ambient air supplied by a blower at the base tower will move upward in a counter current flow to the water. The packing material provides a large surface area where VOCs are transferred from the aqueous to the gaseous phase. The estimated size of the packed tower is 2' diameter by 25' packing height. This is based on the usage of an air-to-water ratio (A/W) of 50 which represents an air flow of 500 cfm. Water stripped of VOCs is collected

Table 4-17

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PRELIMINARY DESIGN CRITERIA - GROUNDWATER PRETREATMENT

System Component	Parameter	Criteria	Groundwater Collection Component		
			2 On-Property Only	3 On-Property, Eastern End of Wetlands	4 On-Property, Middle and Eastern End of Wetlands
1. Flow Equalization	Detention Time	1 hr	V = 4000 gal	10,000 gal	15,000 gal
2. pH Adjustment	Detention Time	15 min.	V = 1000 gal	(2) 1200 gal	(2) 1800 gal
	Velocity Gradient	200 sec^{-1}	P = 1/4 HP	(2) 1/3 HP	(2) 1/2 HP
3. Flocculation	Detention Time	30 min.	V = 2000 gal	(2) 2400 gal	(2) 3500 gal
	Velocity Gradient	70 sec^{-1}	P = 1/10 HP	(2) 1/10 HP	(2) - 1/10 HP
4. Sedimentation (corrugated plate)	Surface Overflow Rate	200 gpd/ft^2	A = 500 ft^2	1000 ft^2	(2) 850 ft^2
5. Neutralization	Detention Time	15 min.	V = 1000 gal	(2) 1200 gal	(2) 1800 gal
	Velocity Gradient	200 sec^{-1}	P = 1/4 HP	(2) 1/3 HP	(2) 1/2 HP

Table 4-17

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PRELIMINARY DESIGN CRITERIA - GROUNDWATER PRETREATMENT

System Component	Parameter	Criteria	Groundwater Collection Component		
			2 On-Property Only	3 On-Property, Eastern End of Wetlands	4 On-Property, Middle and Eastern End of Wetlands
6. Multi-Media Filtration	Filter Rate	<5 gpm/ft^2 (w/one cell off-line)	A = 30 ft^2	80 ft^2	100 ft^2
	Clearwell	5 min. backwash	V = 1125 gal	3000 gal	3750 gal
	Mudwell		V = 1750 gal	3400 gal	4250 gal
7. Sludge Thickener	Detention Time	16 hrs.	V = 900 gal	1500 gal	2000 gal
Filter Press	Volume		V = 12 ft^3	20 ft^3	25 ft^3

Note:
V = Volume
P = Power
A = Area
(2) = Indicates two treatment trains

in a sump at the base of the tower and pumped to polishing GAC units prior to discharge. Off gas treatment can be accomplished through vapor phase carbon or catalytic oxidation with caustic scrubber. The preliminary design criteria for the air stripper and associated air emission control systems are presented in Table 4-18.

The regulatory threshold for uncontrolled VOC emissions in the State of Massachusetts is one ton per year (i.e, approximately 5.5 pounds per day). Emission rates above this threshold limit require an emission control system or an air discharge permit from the Massachusetts DEP Division of Air Quality Control. Based on the total concentrations of BTEX, 1,2-dichloroethene, tetrachloroethene, trichloroethene, and vinyl chloride (see Table 4-13) entering the air stripper and a total flow rate of 65 gpm, the calculated total annual VOC emission rate (i.e., assuming 100 percent removal from the aqueous phase) from the air stripper is 7.7 lbs/day or 1.4 tons/yr. Based upon this analysis, the DEP will require the off-gases to be treated to remove 95% of the VOCs.

A major deciding factor on the type of off-gas treatment for this option is the presence of vinyl chloride. Vapor phase carbon has a very low capacity for absorbing vinyl chloride. Based on the estimated concentration in the groundwater (125 $\mu g/l$) and the proposed air flow rate of 500 cfm, the adsorption capacity is 0.001 lb. vinyl chloride per pound of carbon. This ratio represents 90 lbs. carbon/day for vinyl chloride alone. Considering all the anticipated contaminants in the groundwater, the estimated total carbon usage is 150 lb/day at initial concentrations. This usage rate would decrease with time as groundwater concentrations decrease. In contrast, the total VOC concentration of 40 ppm-v in the gas stream is fairly low for a catalytic oxidizer and the use of such a system would require a supplemental fuel source. Based on the levels of chlorinated compounds in the air stream entering the catalytic oxidizer, the estimated HCl concentration in the off-gas from the catalytic oxidizer is 18,000 $\mu g/m^3$. Based on this concentration, the estimated 24-hour and annual impacts are 63.5 and 0.15 $\mu g/m^3$, respectively. The Massachusetts DEP Allowable Ambient Limit (AAL) for hydrochloric acid is 2.0 $\mu g/m^3$ (24-hr and annual). Based on the 63.5 $\mu g/m^3$ 24-hour impact, additional treatment (i.e., caustic scrubbing) would be required. The costs associated with both off-gas treatment technologies are presented in Section 4.8.

Table 4-18

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
PRELIMINARY DESIGN CRITERIA - GROUNDWATER TREATMENT

System Component	Parameter	Criteria	Groundwater Collection Component		
			2 On-Property Only	3 On-Property, Eastern End of Wetlands	4 On-Property, Middle & Eastern End of Wetlands
1. Air Stripper	Air-to-Water Ratio	50	500 cfm	750 cfm	1500 cfm
	Liquid Loading Rate	<30 gpm/ft^2	ϕ = 2 ft	ϕ = 3 ft	ϕ = 3.5 ft
	Packing Depth		H=25'	H = 24'	H = 25'
	Off-gas Concentration		40 ppm-v	20 ppm-v	15 ppm-v
Vapor Phase Carbon	Carbon Usage*		140 lb/d	220 lb/d	270 lb/d
Catalytic Oxidizer	Natural Gas Usage		3.6 scfm	7.6 scfm	11.5 scfm
2. Liquid Phase Carbon	Carbon Usage*		300 lb/d	540 lb/d	700 lb/d
	Detention Time	>15 min.	165 min	70 min	45 min
3. Chemical Oxidation	Energy Input		60 KW	180 KW	180 KW

Notes:
* Based on initial contaminant concentrations
ϕ = diameter
H = height

4.7.2.2 Component 2 with Liquid Phase Carbon

Groundwater contaminated with BTEX and Cl-VOC will be pumped to four 10,000 lb. carbon contactors (two parallel sets in series). By operating the columns in series, the utilization of the first stage carbon columns is maximized by allowing primary columns to be operated beyond the breakthrough point. The secondary columns would remove contaminants which breakthrough the first stage. Upon complete exhaustion of the carbon in the lead column, the spent carbon would be removed for off-site regeneration and the unit filled with regenerated carbon. As with the vapor phase carbon, liquid phase carbon has a very low capacity for vinyl chloride (0.0005 lb. vinyl chloride/lb. carbon). The estimated carbon usage at initial concentrations is 300 lbs/day. Usage at these rates would require replacing the carbon in the lead columns every two months, although the frequency of removal would decrease with time as influent concentrations decreased. The preliminary design criteria for a liquid phase GAC system is presented in Table 4-18.

4.7.2.3 Component 2 with Chemical Oxidation

For the purpose of this FS, the chemical oxidation process is assumed to use hydrogen peroxide as the oxidizing agent. When hydrogen peroxide is catalyzed with ultraviolet (UV) light, hydroxyl radicals are formed, which react with the organic contaminants. Hydrogen peroxide contains no metals or halogens which can lead to undesirable by-products during the oxidation process. In addition, with this treatment there will be no need for off-gas treatment. The compounds that are present (BTEX, DCE, TCE, PCE, and vinyl chloride) are easily oxidized with required oxidation times of less than one minute. The proposed oxidation unit to treat the contaminated groundwater is rated at 60 KW and can handle flows up to 100 gpm. As with the air stripper, the chemical oxidation unit will be followed by a polishing GAC unit. The preliminary design criteria (energy usage) is summarized in Table 4-18 for the different collection components.

4.7.3 Component 3: Treatment of On-Property and Eastern End of Wetlands Groundwater

This component involves treating the water with the highest level of contamination (on-property groundwater) and groundwater with the lowest level of contamination (groundwater at the far eastern end of the wetland). Based on the estimated cleanup times, the treatment system under this component would operate for 65 years.

The on-property recovery and collection system is the same as that described in Section 4.7.2. The recovery system in the wetlands includes one overburden well with a flow rate of 75 gpm and three bedrock wells (5 gpm/each). The total flow rate from the wetlands is 90 gpm with the characteristics presented in Table 4-14. The recovered groundwater will be pumped through approximately 3900 feet of piping (with secondary containment) to combine with on-property groundwater. The combined flow has estimated characteristics as indicated in Table 4-15. The combined groundwater would require pretreatment for iron (i.e., 50 mg/l iron is significantly higher than the recommended 5 mg/l maximum). The pretreatment would be the same as that for the on-property groundwater, namely, oil/water separation, equalization, chemical precipitation, flocculation, sedimentation, neutralization, and filtration. Sludge handling would also include thickening and dewatering. The estimated quantity of sludge to be disposed annually is 1600 ft^3. The filtered water will be pumped from the filter clearwell to the VOC removal step (air stripping, carbon adsorption or chemical oxidation). These primary treatment options are discussed below to the degree that they differ with the description of the on-property only system. Preliminary design criteria for the pretreatment and VOC treatment options are presented in Table 4-17 and 4-18, respectively.

60 cu yd

4.7.3.1 Component 3 with Air Stripping

The estimated sizing of the packed tower is 3.0' diameter by 24' packing depth. This sizing is based on an A/W ratio of 50 which represents an air flow of approximately 1000 cfm.

The estimated VOC emission rate is 8.1 lb/day (1.5 ton/year). This emission rate is above the regulatory threshold of 1 ton/yr, and therefore treatment of air emissions will be required. The estimated carbon usage rate is 220 lb/d based on initial groundwater concentrations. The total VOC concentration in the gas stream is 20 ppm-v.

4.7.3.2 Component 3 with Liquid Phase Carbon

The system would include four 10,000 lb contactors (two parallel sets, operated in series). The presence of vinyl chloride again decreases the efficiency of liquid phase carbon. The estimated carbon usage is 540 lb/d for the estimated initial concentrations, which would require replacement of the carbon in the lead columns every month.

4.7.3.3 Component 3 with Chemical Oxidation

The proposed system is a 180 KW unit.

4.7.4 Component 4: Treatment of On-Property and Wetland Groundwater

This component involves treating the water with the highest level of contamination (on-property groundwater) and the groundwater from two locations in wetlands with discharge of treated water to several wetland locations. Based on the cleanup time for the wetlands, the treatment system would be operated for 35 years.

The on-property recovery and collection system is the same as that described in Section 4.7.2. The wetlands recovery system involves two overburden wells (75 gpm/each) and six bedrock wells (5 gpm/each) for a total flow of 180 gpm. The wetlands groundwater would have the characteristics presented in Table 4-14. The recovered groundwater will be pumped through approximately 4400 feet of piping (with secondary containment) to combine with on-property groundwater into a single flow with the characteristics in Table 4-16. The on-property groundwater would require pretreatment for TPH and iron and the wetlands groundwater would require iron removal. The on-property groundwater would pass through an oil/water separator to the equalization tank. The groundwater from the wetlands would be pumped directly to equalization. The pretreatment system following equalization would be the same as with the other groundwater components: lime precipitation, flocculation, sedimentation, neutralization and filtration. Sludge handling would also include thickening and dewatering. The estimated quantity of sludge disposed annually is 2000 ft^3. The filtered water will be pumped from the filter clearwell to the VOC removal step (air stripping, carbon adsorption, or chemical oxidation). These primary treatment options are discussed below to the degree that they differ from the description of the on-property only system.

4.7.4.1 Component 4 with Air Stripper

The estimated sizing of the packed tower is 3.5' diameter by 25' packing depth. This sizing is based on an A/W ratio of 50 which represents an air flow of approximately 1500 cfm.

The estimated VOC emission rate is 8.3 lb/d (1.5 ton/year). The off-gases will need to be treated to remove 95% of the VOCs, in that the regulatory threshold of 1 ton/yr will be exceeded. The total VOC concentration in the gas stream is 15 ppm-v. As with the on-property only system, deciding factors in determining which vapor treatment technology is most feasible is the presence of vinyl chloride and relatively low vapor concentrations. The estimated vapor carbon usage is 270 lb/d at initial design concentrations.

4.7.4.2 Component 4 with Liquid Phase Carbon

The system includes four-10,000 lb contactors (two sets in parallel, operated in series). The presence of vinyl chloride again impacts the effectiveness of liquid phase carbon, with an estimated carbon usage of 700 lb/d. This usage would require replacement of the carbon in the lead columns every month.

4.7.4.3 Component 4 with Chemical Oxidation

The proposed system is a 180 KW unit.

4.8 SELECTION OF GROUNDWATER TREATMENT COMPONENT

In Section 4.5, four groundwater collection components were developed: no pumping, on-property wells only, on-property wells and eastern end of wetland wells, and on-property wells and wells in the middle and eastern end of the wetlands. In the following discussion groundwater treatment components are evaluated for each groundwater collection component in a manner similar to that in Section 4.4. As noted in Section 4.7.1, no treatment is required for the no-action collection component.

The main difference between the groundwater treatment components is the technology used for VOC removal: air stripping (with either vapor phase carbon or catalytic oxidation and caustic scrubbing), liquid phase carbon, and chemical oxidation (UV/hydrogen peroxide). Because the same contaminants are addressed with each collection component, the same primary treatment component will be chosen under each collection component (i.e., Components 2, 3 and 4 will employ the same technology for VOC removal).

Because each of the groundwater treatment systems would be designed to effectively meet discharge requirements, there are few differences between the treatment systems when evaluated using the eight criteria in the MCP. With regards to effectiveness, each of the treatment components is a permanent solution, treats on-site and will achieve background levels. There are no significant risks associated with the implementation or operations of these treatment components. Pertaining to benefits, each treatment component aids in restoring the aquifer and in achieving productive reuse of the site. Timeliness to meet objective is a function of groundwater collection, not groundwater treatment.

The only significant differences are related to reliability, implementability and cost. Air stripping/catalytic oxidation component received a most favorable rating for reliability because it does not have the difficulties associated with removing vinyl chloride with liquid or vapor phase carbon and because these technologies (air stripping and catalytic oxidation) have much more proven field experience than chemical oxidation. Although vinyl chloride has low carbon adsorption capacity, these systems can be designed with a high degree of reliability. It should be noted that vapor phase carbon is significantly more effective than liquid phase carbon (i.e., compare usage rates in Table 4-18). With regards to implementability, the main issues are technical complexity, O&M, availability of services and TSD facility and permits. Air stripping with catalytic oxidation and caustic scrubbing is the most technically complex of the four treatment components. Caustic scrubbing results in an additional aqueous stream which will require further treatment. Air stripping with vapor phase carbon is not technically complex and is easily implemented. Off-site regeneration services are readily available. Both air stripping components will require an air discharge permit. Liquid phase granular activated carbon, although easily implemented, requires significant O&M associated with carbon replacement. Vapor phase carbon units are often rented and the O&M associated with emptying units, packaging and shipping spent carbon and refilling contractors is not a concern. Neither liquid phase carbon or chemical oxidation processes require an air permit. Chemical oxidation equipment has limited availability. Based on these observations, air stripping with vapor phase carbon and liquid phase carbon would receive most favorable ratings, although all four components have implementation advantages and disadvantages. The air stripping/vapor phase carbon treatment component is the least expensive under each collection component (see Table 4-19). Liquid phase carbon has significant O&M cost associated with carbon replacement due to the presence of vinyl chloride. Catalytic oxidation and chemical oxidation have significant energy costs. Based on the high degree of reliability, ease of implementation and lower implementation costs, air stripping with vapor phase carbon is the selected groundwater treatment component.

In conclusion, the selected treatment component for each groundwater collection component is oil/water separation, equalization, lime precipitation, neutralization, filtration, air stripping, and carbon polishing. The sludge from lime precipitation would be thickened and dewatered by filter press. The off-gas from the air stripper would be treated by vapor phase carbon.

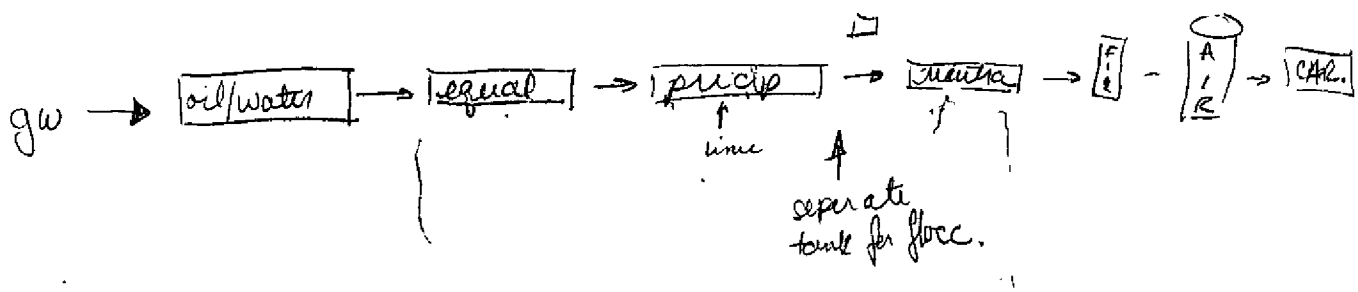


Table 4-19

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
COST SUMMARY FOR GROUNDWATER TREATMENT COMPONENTS

Description of Component	Construction Cost ($)	Future Equipment	Present Worth of Future Equipment	O&M Cost ($/yr)	Present Worth of O&M	Groundwater Monitoring Cost ($/YR)	Present Worth of Groundwater Monitoring	Total Present Worth
Component 1 – No Action	0	0	0	0	0	20,000	330,000[1]	330,000
Component 2 – On-Property Only								
1. Air Stripping & Vapor Phase Carbon	1,793,000	0	0	252,000	2,890,000[2]	20,000	330,000[1]	5,013,000
2. Air Stripping & Catalytic Oxidation	2,379,000	0	0	230,000	2,638,000[2]	20,000	330,000[1]	5,347,000
3. Liquid Phase Carbon	2,656,000	0	0	348,000	3,992,000[2]	20,000	330,000[1]	6,978,000
4. Chemical Oxidation	2,262,000	0	0	268,000	3,074,000[2]	20,000	330,000[1]	5,666,000
Component 3 – On-Property and Eastern End of Wetlands								
1. Air Stripping & Vapor Phase Carbon	3,409,000	2,924,000	598,000[3]	376,000	5,672,000[4]	20,000	326,000[5]	10,005,000
2. Air Stripping & Catalytic Oxidation	4,128,000	4,002,000	818,000[3]	349,000	5,266,000[4]	20,000	326,000[5]	10,538,000
3. Liquid Phase Carbon	3,713,000	3,380,000	691,000[3]	674,000	10,170,000[4]	20,000	326,000[5]	14,900,000
4. Chemical Oxidation	4,392,000	4,398,000	920,000[3]	496,000	7,482,000[4]	20,000	326,000[5]	13,100,000

Table 4-19

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
COST SUMMARY FOR GROUNDWATER TREATMENT COMPONENTS

Description of Component	Construction Cost ($)	Future Equipment	Present Worth of Future Equipment	O&M Cost ($/yr)	Present Worth of O&M	Groundwater Monitoring Cost ($/YR)	Present Worth of Groundwater Monitoring	Total Present Worth
Component 4 -- On-Property and Entire Wetlands								
1. Air Stripping & Vapor Phase Carbon	3,746,000	1,754,000	547,000[6]	421,000	5,850,000[7]	20,000	290,000[8]	10,433,000
2. Air Stripping & Catalytic Oxidation	4,464,000	2,328,000	726,000[6]	396,000	5,502,000[7]	20,000	290,000[8]	10,982,000
3. Liquid Phase Carbon	3,950,000	1,917,000	598,000[6]	807,000	11,212,000[7]	20,000	290,000[8]	16,050,000
4. Chemical Oxidation	4,630,000	2,462,000	768,000[6]	525,000	7,294,000[7]	20,000	290,000[8]	12,982,000

1 P/A (6%, 80 yrs) = 16.5091
2 P/A (6%, 20 yrs) = 11.4699
3 P/F (6%, 20 yrs) + P/F (6%, 40 yrs) = 0.4090; replacement of 155 gpm treatment plant with a 90 gpm treatment plant in years 20 & 40
4 P/A = (6%, 20 yrs) + .75 [P/A (6%, 65 yrs) - P/A (6%, 20 yrs)] = 15.0843
5 P/A (6%, 65 yrs) = 16.2891
6 P/F (6%, 20 yrs) = 0.3118; replacement of 230 gpm treatment plant with a 180 gpm treatment plant in year 20
7 P/A = P/A (6%, 20 yrs) + .8 [P/A (6%, 35 yrs) - P/A (6%, 20 yrs)] = 13.8925
8 P/A (6%, 35 yrs) = 14.4982

5.0 IDENTIFICATION AND EVALUATION OF REMEDIAL ACTION ALTERNATIVES

5.1 OVERVIEW OF REMEDIAL ACTION ALTERNATIVE EVALUATION

In this section the remedial action alternatives under consideration for the 50 Fordham Road site will be described and evaluated. The criteria used in the evaluation are those specifically set forth in the Massachusetts Contingency Plan (MCP) under M.G.L. 310 CMR 40.0858. The purpose of these criteria is to establish a uniform basis for evaluation of each of the remedial action alternatives so that the alternatives can be compared to one another, and a remedial action alternative selected for implementation at the site. The selection of an alternative is discussed in Section 6.0.

The criteria used in the detailed evaluation process are as follows:

1. Effectiveness
2. Reliability
3. Implementability
4. Cost
5. Risk
6. Benefits
7. Timeliness
8. Non-Pecuniary Issues

The criteria referred to above are as previously defined in Section 4.4.

5.2 DESCRIPTION OF REMEDIAL ACTION ALTERNATIVES

Section 4.0 included the description of soil treatment components, groundwater collection components, and groundwater treatment components which will be combined in this section to form remedial action alternatives which address the entire site. As described in Section 4.1, to simplify the evaluation of remediation action alternatives, evaluation and selection of the soil treatment and groundwater treatment components was conducted in Section 4.0. These evaluations resulted in the selection of a soil treatment component which consists of soil vapor extraction in the Tank K and Tank Farm areas, with excavation of soil/sediment at the Eastern Parking Lot, Drum Storage Areas, and Outfall Basin 001 and subsequent treatment of these soils/sediment at an off-site thermal desorption facility. With respect to groundwater treatment, the selected components consist of the following sequence of treatments; oil/water separation, equalization, increase in pH with metals precipitation, neutralization and filtration, removal of VOCs with an air stripper followed by off-gas treatment with vapor phase carbon, carbon polishing, and discharge of treated water to surface water in the wetlands.

In this chapter, these soil and groundwater treatment components are combined with three different groundwater extraction components (described in Section 4.5.1.6) to form a range of remedial action alternatives. In addition, a No Action Alternative is included as a basis of comparison.

These four alternatives are described below in detail.

5.2.1 Alternative 1 - No Action Alternative

Under this alternative, no further remedial action will be conducted. Neither the soil on-property, nor the groundwater on-property or in the adjacent wetlands, would be excavated, pumped, or treated/disposed of in any manner. Rather, the current conditions at the site would be allowed to continue indefinitely. Any reduction in contaminant concentrations in either soil or groundwater would occur over an extremely long time period by natural attenuation processes. For cost comparison purposes, it is assumed that monitoring of site conditions would be conducted for an 80 year period of time.

5.2.2 Alternative 2 - On-Property Wells Only, Groundwater Treatment On-Property and Soils Remediation

The selected component for soil remediation at the site was developed in Section 4.4. In general terms, it consists of soil vapor extraction at Tank K and in the Tank Farm area, excavation of soils in the Eastern Parking Lot, the Drum Storage Area and Outfall 001, and off-site thermal desorption treatment of excavated soils and sediment. This component is described in greater detail below:

Soil Excavation and Treatment

For the purpose of this FS, the total volume of contaminated soil/sediment requiring excavation was estimated to be approximately 8,000 cubic yards (approximately 11,000 tons). Prior to the remedial design, additional soil sampling will be conducted to more accurately define the extent of contamination. The areas which would be excavated are the Eastern Parking Lot, Drum Storage Area and Outfall 001. For the most part, the excavation would be conducted utilizing sheet piling. Sheet piling will serve three purposes:

1. allow the excavation to be carried out in stages, minimizing disruption to the site;
2. aid in the recovery of separate phase product by minimizing collection of uncontaminated water; and
3. prevent recontamination of remediated areas.

Prior to the initiation of any field activities, a sampling program will be developed that defines the number of samples to be collected and analytical parameters to be analyzed as the soil is excavated. Strict adherence to this sampling program would be necessary in order to separate those soils which could be replaced in the excavation (i.e., no cleanup objectives exceeded) versus those soils which would require treatment. The excavated material would initially be screened both visually, and by instrumentation (e.g., a photoionization detector). Visual screening would be done throughout the excavation process, while the photoionization detector would be used to screen a minimum of every 10 cubic yards of excavated materials. Soils with recorded measurements greater than 10 ppm of the photoionization detector would be temporarily stockpiled at an area designated as requiring treatment. Conversely, excavated soils with recorded measurements less than 10 ppm on the photoionization detector, and no visual evidence of contamination, would be temporarily stockpiled at an area designated as potentially clean soil.

Once the soils are stockpiled, one sample per every 250 cubic yards of material would be collected and submitted to a laboratory for chemical characterization. The samples, designated as requiring treatment, would be analyzed for total petroleum hydrocarbons, volatile organics, semi-volatile organics, polychlorinated biphenyls, ignitability, corrosivity, reactivity, TCLPs, metals, herbicides and pesticides, as required by the off-site thermal desorption facility. If the analytical results indicate that no soil cleanup objectives are exceeded and the soil is not considered a hazardous waste by characteristic, the soil would be used as backfill. If the analytical results verify the need for treatment, the soils would be loaded onto trucks and transported to an off-site thermal desorption facility.

The soil designated as potentially clean soil would be analyzed for total petroleum hydrocarbons and VOCs to determine if cleanup objectives are exceeded. If the analytical results verify that no soil cleanup objectives are exceeded, the soil would be used as backfill. If the analytical results indicate the need for treatment, the soils would be analyzed for the additional parameters required by the off-site treatment facility. These soils would also be loaded onto trucks and transported to an off-site thermal desorption facility.

Due to the uncertainty of the levels of chlorinated compounds in the Eastern Parking Lot and Drum Storage Area soil, the selection of thermal desorption assures all excavated soils and sediment can be addressed. Off-site thermal desorption was selected for the following reasons: 1) remediation activities are less complex and more reliable at an established facility; and 2) less disruption will occur to existing operations. However, as was noted in Section 4.4.2, the ex-situ treatment of excavated soils could potentially be handled by thermal desorption (on- or off-site) or asphalt batching (on- or off-site). A final selection would be based on additional soil sampling performed prior to remedial design.

During the excavation of the Eastern Parking Lot, separate phase Stoddard solvent would be recovered. Although the details of such recovery will be developed in the remedial design, a brief description is provided below. Areas (approximately 50' x 50') would be blocked off by sheet piles. Excavated soil would be handled according to the sampling protocol indicated above to minimize the quantity of soil requiring transportation and treatment. Soil would be excavated approximately a foot below the groundwater table, and skimmers would be placed in the excavation to recover product which was not removed with the excavated soil. The recovered product/water mixture would be pumped through an oil/water separator and then through activated carbon. Effluent from the activated carbon would be sampled periodically to verify that it meets NPDES discharge limits. The treated groundwater would be discharged to the wetlands and the recovered product drummed and shipped off-site for treatment (incineration). Once the product is removed, the excavation would be filled with a combination of excavated material which did not require treatment and clean fill transported from off-site. The sheet piling would be left in place until the portion of the Eastern Parking Lot requiring remediation had been excavated to prevent recontamination of areas which were remediated.

Soil Vapor Extraction

The selected soil component of the remedial action alternatives includes soil vapor extraction systems in the Tank Farm and the Tank K Areas. The conceptual design of the soil vapor extraction systems is described below:

Extraction Wells - Extraction wells are similar in construction to monitoring wells. The proposed systems would use 4-inch PVC casing and screening. A highly permeable sand or gravel packing would be placed around the screen for optimal gas flow to the well. Above the pack, bentonite would be used to seal the hole. Multiple wells are proposed for both areas (3 wells in the Tank Farm and 5 wells at Tank K), and would be placed so that the flow zone intercepts the contaminated zone. The screened interval would extend from just above the existing water table to the water table depression caused by the groundwater collection system.

Blower - The driving force for the creation of a vacuum in the soil would be a positive displacement blower, a centrifugal blower or vacuum pump. A vacuum of 2 inches to 4 inches Hg for gravelly and sandy soils would be required to account for pressure losses in the collection system. The total flowrate for two systems would be 500 scfm (Tank K) and 750 scfm (Tank Farm). The influent header from the wells to the blower would be equipped with a vacuum indicator and manual flow control valve. The effluent pipeline would be equipped with a pressure indicator, temperature indicator and automatic discharge valve.

Piping - Manifold piping would connect the extraction wells and the blower/emission control system. The piping would be constructed of PVC, installed below ground and insulated, as necessary, to prevent freezing of condensed water. Piping would be sloped back toward the well. The manifold system would contain flow and pressure meters (to allow measurement during system operation) and flow control valves. Valves would be used to control which wells would be active at any one time.

Vapor Pretreatment - Vapors exiting the extraction wells may contain moisture and fine silt particles that may impair mechanical devices and vapor treatment operations. Air/water separators (knock-out drums) would be used to reduce moisture. Knock-out drums decrease the velocity of the incoming vapor stream, and allow gravity to separate dirt and the heavier liquid molecules from the lighter vapor stream. The removed water would be pumped to the groundwater treatment plant. In order to ensure acceptable adsorption of carbon is used for vapor treatment (i.e., in the Tank Farm Area), a heat exchanger would be provided to cool the extracted vapors due to the temperature increase caused by the blower.

Emission Control - The emissions control system would be the mechanism by which contaminants in the vapor stream would be treated prior to discharge to the atmosphere. For the Tank Farm Area, which has a relatively low estimated vapor concentration, the vapor stream would be passed through a bed of activated carbon. For the Tank K Area, a catalytic oxidizer would be used. Catalytic oxidation units operate by passing the heated vapor stream over a catalyst bed which facilitates combustion.

Groundwater Collection

Under this alternative, groundwater would be extracted through a series of wells placed in the vicinity of potential source areas at Tank K, the Eastern Parking Lot, Tank F, and Tank Farm. Three wells at Tank K would extract water from the overburden, while in the Eastern Parking Lot area, groundwater would be extracted from both the deep overburden and bedrock (three overburden/bedrock couplets would be placed along the eastern side of the Eastern Parking Lot). Four bedrock wells would be interspersed throughout the remaining area of the Eastern Parking Lot and the Tank Farm, with an additional bedrock well in the Tank F location and an overburden/bedrock couplet near the southern property boundary. In summary, groundwater would be collected through a total of three overburden wells at Tank K, and four overburden and nine bedrock wells in the Eastern Parking Lot and Tank Farm Area. The existing TF-1 bedrock well at the Tank Farm is included in the above total and would continue to be used.

These wells, once installed, would yield an estimated flow of approximately 65 gallons per minute. This flow would be pumped from the various wells and transmitted to a proposed groundwater treatment facility to be located in the vicinity of the existing basketball courts in the northeastern corner of the paved parking area by means of double-walled buried piping. Treated water would be discharged to surface wetland waters. The approximate locations of the proposed extraction wells, collection piping, and groundwater treatment system are shown on Figure 5-1.

Groundwater Treatment

The proposed groundwater treatment system would consist of the following unit processes:

Oil/Water Separator - The purpose of the oil/water separator would be to remove separate phase product, such as gasoline or Stoddard solvent, which will float on top of the water and can be skimmed off, thus reducing the contaminant loading on the following process units in the treatment train. Separate phase product that is skimmed off would then be transferred to a product storage tank and allowed to accumulate prior to final disposal off-site.

Equalization Tank - The equalization tank would serve to dampen out wide swings in flow by allowing water to accumulate in it during varying inflow conditions, while the water is pumped out of it at a constant rate. Thus, the downstream unit processes would experience a uniform flow rate even if the actual flow rate of water entering the treatment system were to fluctuate with time. The equalization tank would receive inflow from the wells, and also from process units including used filter backwash water, supernatant from the sludge thickener, and filtrate from the filter press.

Precipitation Tank - Water leaving the equalization tank would be pumped into the precipitation tank. Here, certain chemicals (such as lime, sodium hydroxide, etc.) and flocculants would be added and mixed into the water using a propeller like device. The purpose of adding these chemicals would be to cause minerals such as iron, or carbonates of magnesium or calcium, which are naturally dissolved in the

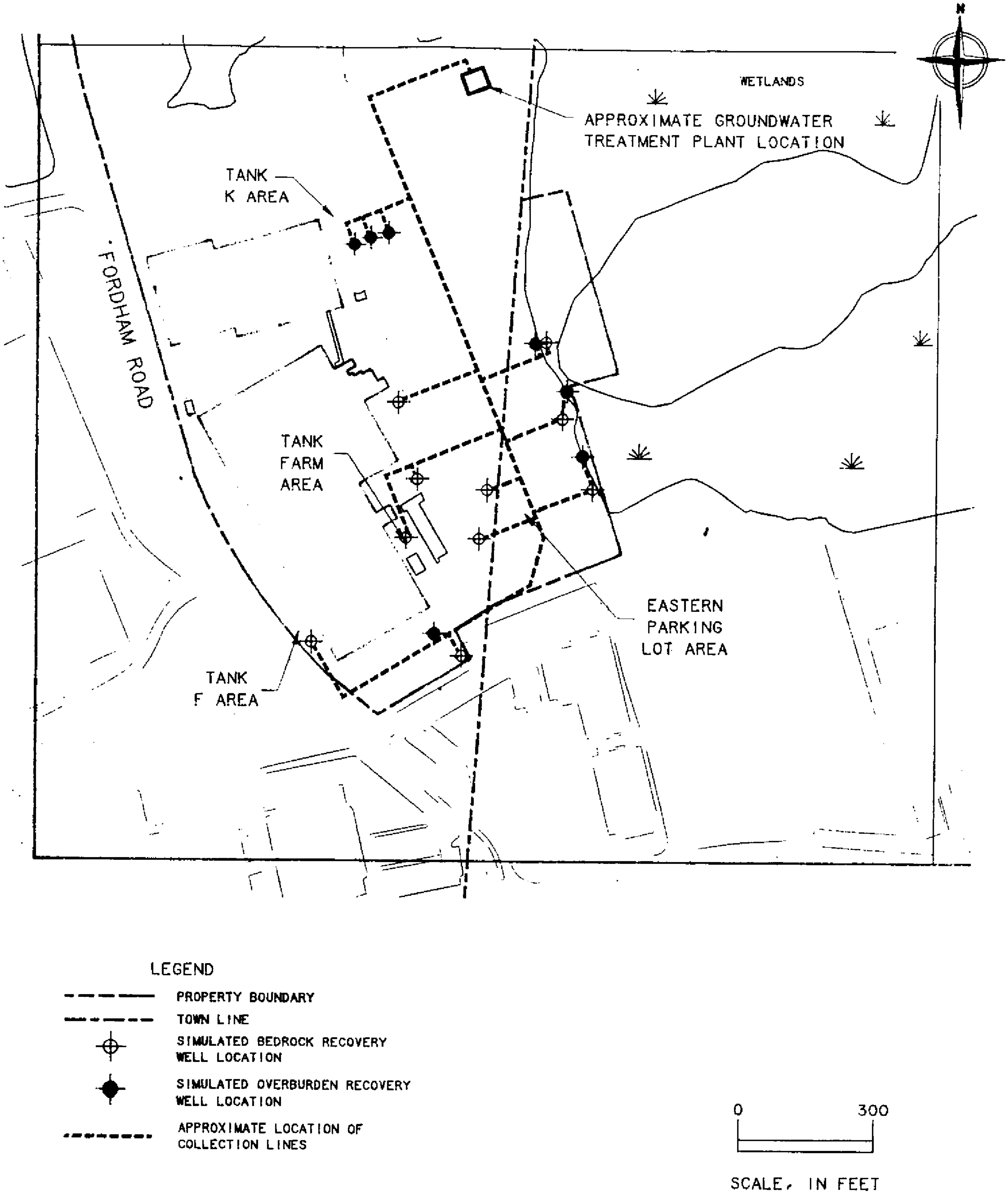


FIGURE 5-1

ON-PROPERTY GROUNDWATER COLLECTION SYSTEM

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO. READING, MASSACHUSETTS

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10/05 DCM:'0150... GTON PROPERTY COLLECT SYSTEM DWG:PS109307

WEHRAN PROJECT NO. 01501.0

water, to precipitate as a solid form so they can be flocculated and settled out of the flow stream, thus removing them before they can cause problems in downstream process units, such as scaling and plugging of packing in stripping towers, or plugging of carbon filters.

Flocculation Tank - The flocculation tank is a large unit where flow velocities are reduced and the water gently agitated to promote contact between adjacent particles which have transitioned from the dissolved into the solids phase. This agitation and contact would cause the development of even larger particles (flocs) which, after agglomeration, can be settled out.

Settling Tank - In this tank the flocculated particles enter a quiescent zone where they would slowly fall to the bottom of the tank and collect as a sludge. The collected sludge, once removed, would be pumped to a sludge thickener for dewatering. Supernatant from the sludge thickener would be returned to the equalization tank.

Neutralization Tank - As part of the precipitation process, lime would be added to the water to raise the pH to about 9 or 10 and facilitate precipitation. In the neutralization tank, acid would be flash mixed into the settled water to reduce the pH to neutral.

Filter Beds - Filter beds would remove any solids which may have passed through the settling tank without having been removed. This would protect the subsequent process units from a solids problem. The filters consist of granular media which would be backwashed with clean water automatically once the surface of the filter became plugged. After backwashing was complete, the used backwash water would be returned to the equalization tank.

Packed Tower - From the filter beds, the water would be pumped to the top of the packed tower, where it would trickle downward through densely packed media. The media usually consist of plastic spheres less than 2" in diameter, which as the water passes over them, have the effect of greatly increasing the surface area of the water trickling through. As the water trickles down, air would be blown upward through the tower. As the air passes over the thin film of water on the media, the air would strip the volatile contaminants from the water and carry them away in the air stream. The water would then pass from the packed tower into the liquid phase granular activated carbon for further treatment, and the air would pass through a vapor phase granular activated carbon.

Sludge Thickener - Sludge pumped from the flocculation settling tank would enter the sludge thickener and remain there for 16 - 20 hours during which time it would densify, and water would separate out and float on top. The water would be drawn off and returned to the equalization tank. The sludge would then be pumped to the filter press.

Granular Activated Carbon - The liquid phase granular activated carbon would clean the water that has left the packed tower, and adsorb most remaining contaminants in a polishing step. The water would then be discharged to the surface of the wetlands via a discharge pipe approximately 1800 feet in length (1000 feet of which is installed in the wetlands). Vapor phase granular activated carbon would perform a similar task for air bearing contaminants exiting the air stripper.

The proposed layout of the discharge piping is shown on Figure 5-2. A flow diagram of the groundwater treatment system can be seen on Figure 5-3. The preliminary design criteria for each of the groundwater treatment process units described above for Alternative 2 can be found in Tables 4-17 and 4-18. The preliminary design criteria for the soil remediation component of Alternative 2 can be found in Table 4-2.

5.2.3 Alternative 3 - On-Property Wells, Wells at the Eastern End of the Wetlands, and Soils Remediation

This alternative is identical to Alternative 2 with regards to the on-property groundwater extraction system, and the soils remediation component. Alternative 3, however, is supplemented by the following:

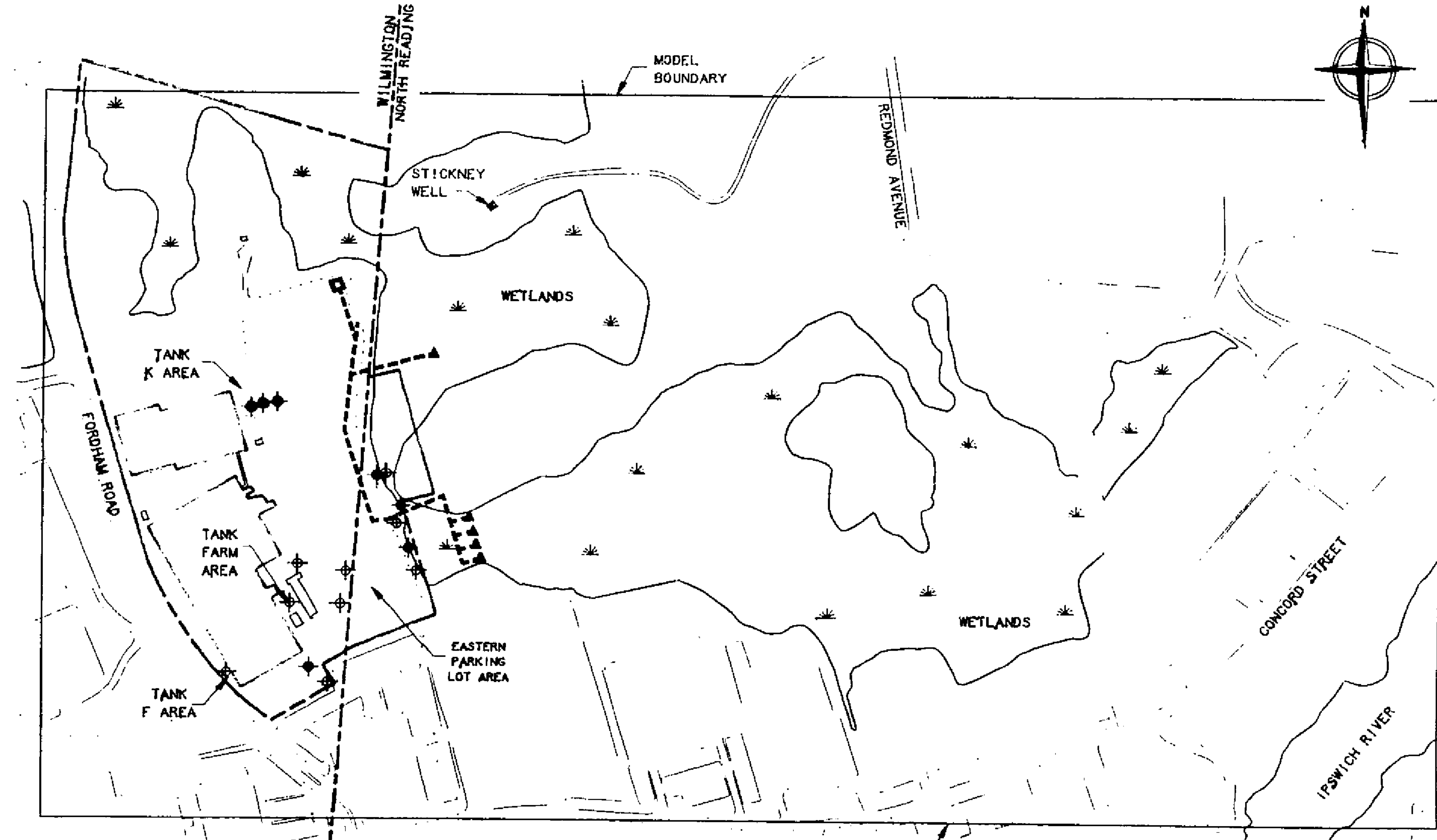

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FIGURE 5-2

ALTERNATIVE 2, OFF-PROPERTY DISCHARGE SYSTEM

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO READING, MASSACHUS

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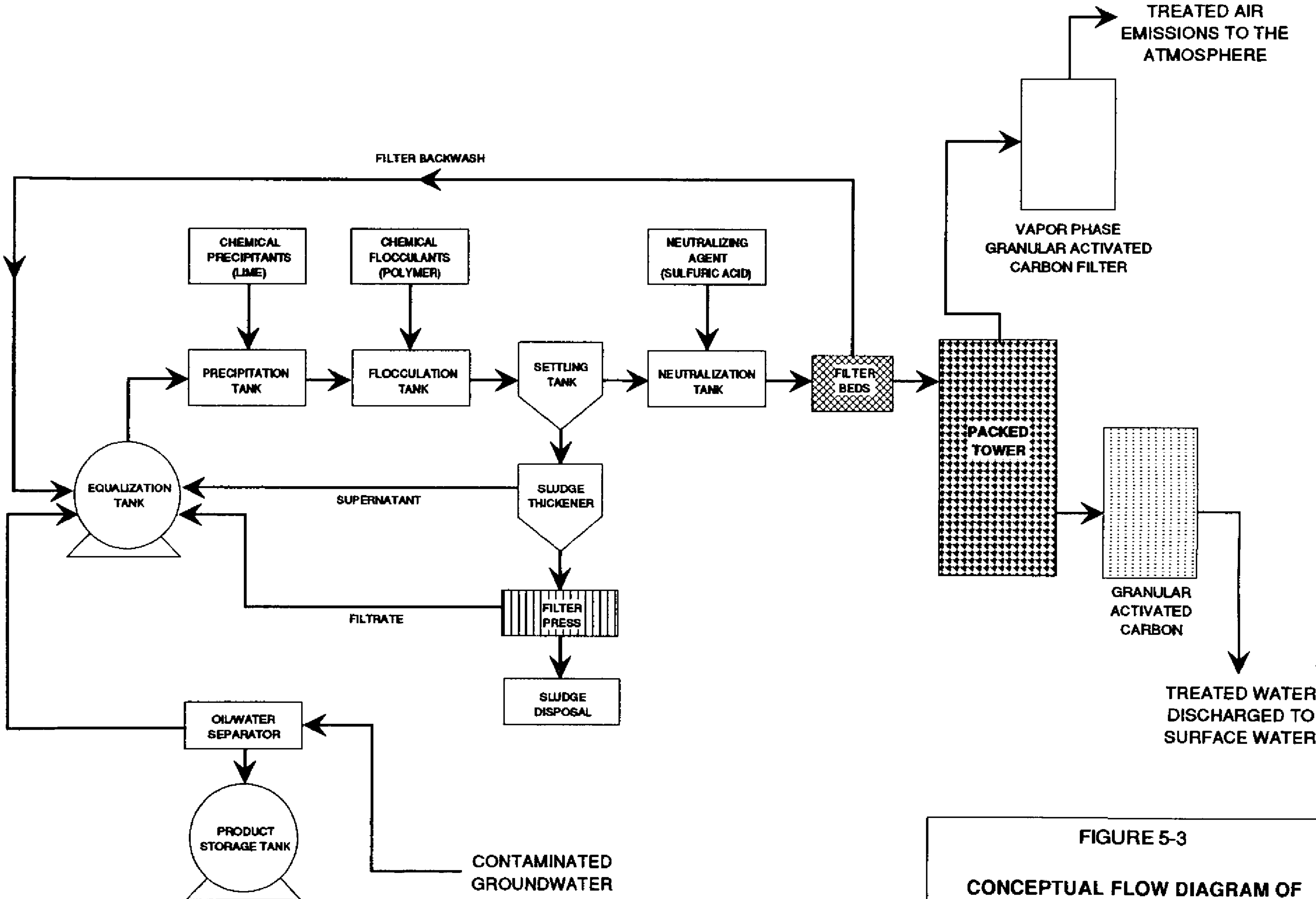

WehranEnviroTech

NOT TO SCALE

FIGURE 5-3

CONCEPTUAL FLOW DIAGRAM OF GROUNDWATER TREATMENT SYSTEM

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS

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WEHRAN PROJECT NO. 01501.02

1. The groundwater extraction system would include three bedrock wells and one overburden well at the eastern end of the wetlands. The flow from these wells would be piped across the wetlands to the 50 Fordham Road property for treatment in the groundwater treatment system proposed for construction near the existing basketball courts. All other aspects of the groundwater extraction system remain as under Alternative 2.

2. The groundwater treatment system for Alternative 3 would be sufficient to accommodate a 155 gpm flow (as compared to the 65 gpm for Alternative 2) to handle the increased inflow from the added wells at the eastern end of the wetlands. The unit processes utilized for treatment of the groundwater would remain the same as under Alternative 2, as shown in Figure 5-3. Treated groundwater would be discharged to surface water simultaneously at a number of points in the wetlands. The discharge points were chosen to mitigate the effects of groundwater drawdown on wetlands and vegetation caused by the groundwater extraction systems.

The preliminary design criteria for the groundwater treatment system under Alternative 3 are shown in Tables 4-17 and 4-18. The layout of proposed wells, connecting piping, and location of the groundwater treatment facility and discharge piping are shown on Figure 5-4.

5.2.4 Alternative 4 - On-Property Wells, Wells at the Middle and Eastern End of the Wetlands, and Soils Remediation

This alternative is identical to Alternative 2, with regards to the on-property groundwater extraction system and soils remediation component. Alternative 4 also includes the following:

1. The groundwater extraction system would include three bedrock wells and one overburden well in the middle of the wetlands, and three bedrock wells and one overburden well at the eastern end of the wetlands. The flow from each of these wells would be piped across the wetlands to the 50 Fordham Road property for treatment in the groundwater treatment system proposed for

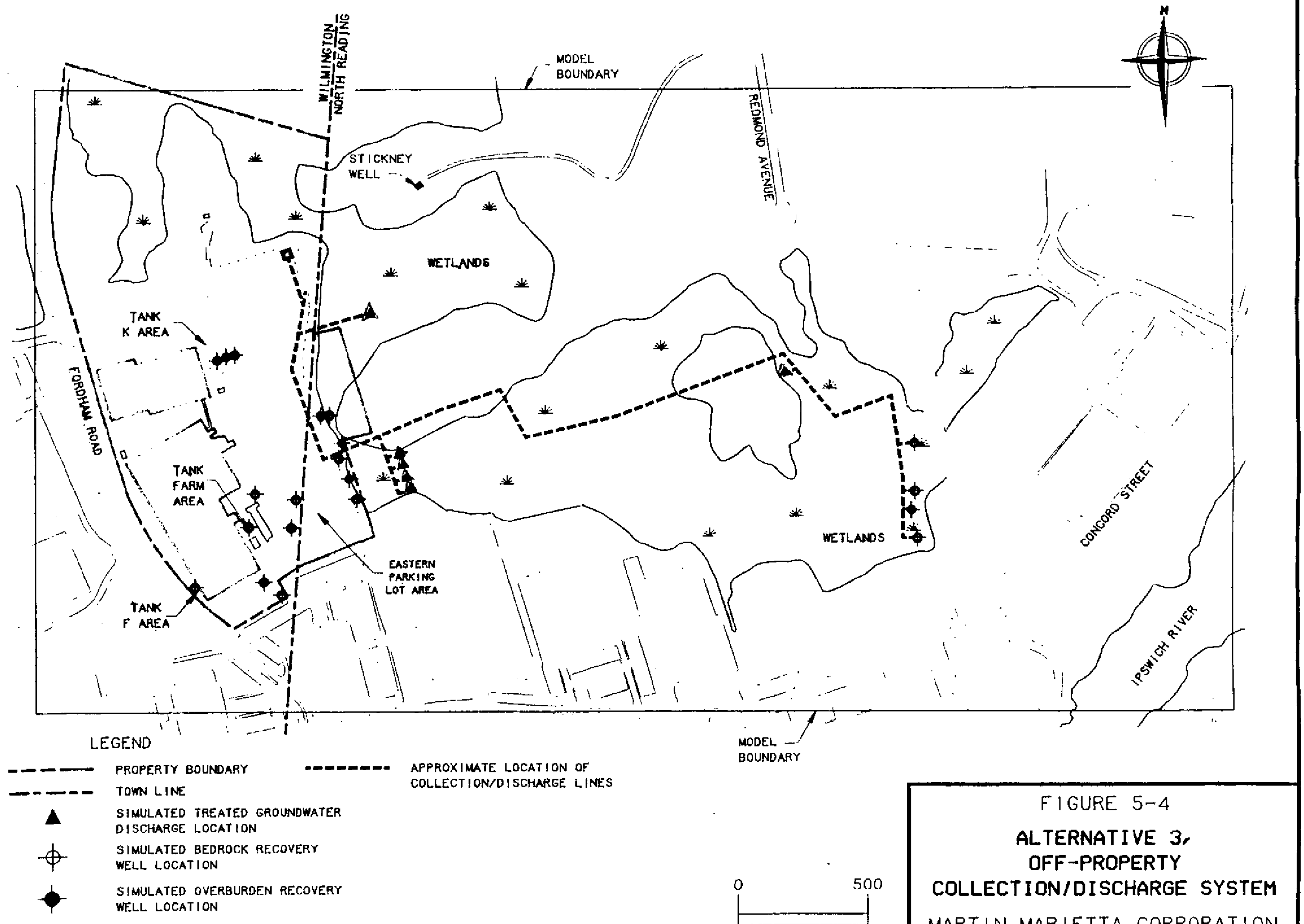

FIGURE 5-4

ALTERNATIVE 3, OFF-PROPERTY COLLECTION/DISCHARGE SYSTEM

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO READING, MASSACHUSETTS

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Wehran Engineering Corporation

10/04 DCM: '01501.02.H6)ACP ALT THREE DWG:PS109305 construction near the existing basketball courts. All other aspects of the groundwater extraction system remain as under Alternative 2.

2. The groundwater treatment system for Alternative 4 would be sufficient to accommodate a 245 gpm flow. The unit processes utilized for treatment of the groundwater remain the same as under Alternative 2. Discharge of treated groundwater would be to surface water simultaneously at different points in the wetlands. The proposed discharge points were chosen to mitigate the effects of groundwater drawdown on wetlands vegetation caused by the groundwater extraction systems.

The preliminary design criteria for the expanded groundwater treatment system under proposed Alternative 4 are shown in Tables 4-17 and 4-18. The layout of proposed wells, connecting piping, and location of the proposed groundwater treatment facility are shown on Figure 5-5.

5.3 DETAILED EVALUATION OF REMEDIAL ACTION ALTERNATIVES

As part of the process leading to the selection of a remedial action alternative for implementation at the 50 Fordham Road site, a detailed evaluation of the four remedial action alternatives was conducted. This evaluation consists of a comparison of each alternative with respect to the evaluation criteria outlined in the MCP under 310 CMR 40.858, and is described below. Table 5-1 provides a summary of this evaluation process.

5.3.1 Remedial Action Alternative 1 - No Action

5.3.1.1 Effectiveness

The No Action Alternative will result in neither a temporary nor a permanent solution, since a level of No Significant Risk will not be achieved in the foreseeable future. In addition, this alternative provides for no reuse, recycling, treatment or destruction on-site of the contaminants. A reduction in concentrations of oil or hazardous materials to achieve or approach background levels would occur only through a process of attenuation or natural degradation. Such a reduction is not likely to occur in the foreseeable future.

In summary, the No Action Alternative would not be an effective alternative.

Table 5-1

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
EVALUATION OF REMEDIAL ACTION ALTERNATIVES

EVALUATION CRITERIA	REMEDIAL ACTION ALTERNATIVES			
	1 No Action	2* On-Property Wells With Selected Soil Component	3* On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4* On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
1. Effectiveness				
a. Temporary or Permanent	• Neither temporary nor permanent	• Permanent	• Permanent	• Permanent
b. Reuse, Recycling, Destroying or Treating On-site	• None	• Contaminants removed from on-property groundwater are destroyed on-site. Treated water discharged to wetlands. • Contaminants in soil and sediment, (and separate phase product) not reused, recycled, destroyed or treated on-site.	• Contaminants removed from on-property and wetlands groundwater are destroyed on-site. Treated water discharged to wetlands. • Contaminants in soil and sediment, (and separate phase product) not reused, recycled, destroyed or treated on-site.	• Contaminants removed from on-property and wetlands groundwater are destroyed on-site. Treated water discharged to wetlands. • Contaminants in soil and sediment, (and separate phase product) not reused, recycled, destroyed or treated on-site.
c. Achieve or Approach Background	• Does not achieve or approach background	• Groundwater beneath property and wetlands approaches background concentrations. • Soil in excavated areas achieves background. Soil in vapor extracted areas (Tank K and Tank Farm) approaches background.	• Groundwater beneath property and wetlands approaches background concentrations. • Soil in excavated areas achieves background. Soil in vapor extracted areas (Tank K and Tank Farm) approaches background.	• Groundwater beneath property and wetlands approaches background concentrations. • Soil in excavated areas achieves background. Soil in vapor extracted areas (Tank K and Tank Farm) approaches background.
Effective Rating	P	G	G	G

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

Table 5-1

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
EVALUATION OF REMEDIAL ACTION ALTERNATIVES

EVALUATION CRITERIA	REMEDIAL ACTION ALTERNATIVES			
	1 **No Action**	**2*** **On-Property Wells With Selected Soil Component**	**3*** **On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component**	**4*** **On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component**
2. Reliability				
a. Certainty of Success	• Not successful	• High certainty of success to achieve groundwater objectives on property. • Less certainty of success to achieve objectives for groundwater beneath wetlands, because 1) don't control capture and removal of contaminants, 2) greater chance for external variables in flow (pumping or withdrawal by others) over longer time frame, and 3) greater uncertainty in predictions over longer time frame. • High certainty of success to achieve soil/sediment objectives.	• High certainty of success to achieve groundwater objectives on property. • Less certainty of success to achieve objectives for groundwater beneath wetlands, because 1) don't control capture and removal of contaminants, 2) greater chance for external variables in flow (pumping or withdrawal by others) over longer time frame, and 3) greater uncertainty in predictions over longer time frame. • High certainty of success to achieve soil/sediment objectives.	• High certainty of success to achieve groundwater objectives on property. • Moderate certainty of success to achieve objectives for groundwater beneath wetlands because 1) can partially control capture and removal of contaminants, 2) lesser chance for external variables in flow (pumping or withdrawal by others) over shorter time frame, and 3) less uncertainty in predictions over shorter time frame. • High certainty of success to achieve soil/sediment objectives.

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

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	1 No Action	2* On-Property Wells With Selected Soil Component	3* On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4* On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
b. Effectiveness of Measures to Manage Residuals	• No measures	• No measures needed to manage remaining site waste. Effective measures to manage treatment wastes; 1) sludge from metals precipitation sent to hazardous waste landfill, 2) GAC regenerated and condensate sent to TSD facility.	• No measures needed to manage remaining site waste. Effective measures to manage treatment wastes; 1) sludge from metals precipitation sent to hazardous waste landfill, 2) GAC regenerated and condensate sent to TSD facility.	• No measures needed to manage remaining site waste. Effective measures to manage treatment wastes; 1) sludge from metals precipitation sent to hazardous waste landfill, 2) GAC regenerated and condensate sent to TSD facility.
c. Effectiveness of Measures to Control Emissions or Discharges	• No emissions	• Stripping column emissions and soil vapor extraction emissions controlled effectively by vapor-phase carbon.	• Stripping column emissions and soil vapor extraction emissions controlled effectively by vapor-phase carbon.	• Stripping column emissions and soil vapor extraction emissions controlled effectively by vapor-phase carbon.
Reliability Rating	P	G	G	G
3. Implementability				
a. Technical Complexity	• Not complex	• Least complex because requires only on-property extraction wells, and minimal off-property piping.	• Greater complexity because requires wells and piping in wetlands.	• Greatest complexity because requires the most wells and piping in wetlands.

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

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	1 No Action	2* On-Property Wells With Selected Soil Component	3* On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4* On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
b. Integration with Facility Operations	• Not an issue	• Less integration with existing facility operations because system operates for shortest time frame (20 yrs).	• Most difficult integration with existing facility operations because system operates for longest time frame (65 yrs). • Larger system requires more integration.	• Moderate integration with existing facility operations because system operates for medium time frame (35 yrs). • Largest system requires most integration.
c. Monitoring, O&M or Site Access Requirements/Limitations	• Monitoring of wells but no O&M issues.	• Monitoring of wells (80 yrs) and long term O&M for groundwater treatment system (20 yrs). • Requires access agreements for surface discharge.	• Monitoring of wells (65 yrs) and long term O&M for groundwater treatment system (65 yrs). • Requires access agreements for recovery wells at eastern end of wetlands, piping of contaminated and treated water across wetlands, and surface discharge.	• Monitoring of wells (35 yrs) and long term O&M for groundwater treatment system (35 yrs). • Requires access agreements for recovery wells in middle and eastern end of wetlands, and piping of contaminated and treated water across wetlands, and surface discharge.
d. Availability of Services	• Not an issue	• All services readily available.	• All services readily available.	• All services readily available.
e. Availability of Off-site TSD Facilities	• N/A	• Readily available.	• Readily available.	• Readily available.

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

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	1 No Action	2* On-Property Wells With Selected Soil Component	3* On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4* On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
f. Permits	• N/A	• Requires State and Federal permits for drawdown in wetlands, discharge to surface water.	• Requires State and Federal permits for drawdown in wetlands, discharge to surface water, and wells and piping in wetlands. Federal permit may not be approved, because considers whether another feasible and less damaging alternative exists.	• Requires State and Federal permits for drawdown in wetlands, discharge to surface water, and wells and piping in wetlands. Federal permit may not be approved, because considers whether another feasible and less damaging alternative exists.
Implementability Rating	G	G	F	F
4. Cost				
a. Cost of Implementation	• $0.3 million	• $8.3 million	• $13.3 million	• $13.7 million
b. Cost of Restoration	• N/A	• Impact approximately 15,000 square feet of wetlands (approximately 0.5% of total 75 acre wetland area).	• Impact approximately 150,000 square feet (3.5 acres) of wetlands (approximately 5% of total 75 acre wetland area).	• Impact approximately 830,000 square feet (19 acres) of wetlands (approximately 25% of total 75 acre wetland area).
c. Cost of Energy Consumption	• None	• Least energy consumption – system operates 20 years.	• Greatest energy consumption – system operates 65 years.	• Moderate energy consumption – system operates 35 years.
Cost Rating	G	G	P	P

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

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5. Risk				
a. Short Term Risk During Implementation	• None	• Potential short term risks to facility workers during excavation and handling of contaminated materials. • Potential short term risk to off-site receptors from transportation of contaminated materials. • Short term risk to wetlands during construction of pipelines.	• Potential short term risks to facility workers during excavation and handling of contaminated materials. • Potential short term risk to off-site receptors from transportation of contaminated materials. • Short term risk to wetlands during construction of pipelines and installation of four wells.	• Potential short term risks to facility workers during excavation and handling of contaminated materials. • Potential short term risk to off-site receptors from transportation of contaminated materials. • Short term risk to wetlands during construction of pipelines and installation of eight wells.

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

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EVALUATION CRITERIA	REMEDIAL ACTION ALTERNATIVES			
	1 **No Action**	**2*** **On-Property Wells With Selected Soil Component**	**3*** **On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component**	**4*** **On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component**
b. Risk During Operations	• Risk not reduced	• Risk to facility workers and any other nearby receptors minimized by air control systems for vapor extraction and groundwater treatment system. • Potential risk to off-site receptors associated with transportation of sludge and spent carbon from treatment systems. • Risks to wetlands associated with drawdown (15,000 square feet for 20 years).	• Risk to facility workers and any other nearby receptors minimized by air control systems for vapor extraction and groundwater treatment system. • Potential risk to off-site receptors associated with transportation of sludge and spent carbon from treatment systems. • Risk to wetlands associated with construction of a permanent road for operations and maintenance activities. • Risk to wetlands associated with drawdown (150,000 square feet for 65 years).	• Risk to facility workers and any other nearby receptors minimized by air control systems for vapor extraction and groundwater treatment system. • Potential risk to off-site receptors associated with transportation of sludge and spent carbon from treatment systems. • Risk to wetlands associated with construction of a permanent road for operations and maintenance activities. • Risk to wetlands associated with drawdown (830,000 square feet for 35 years).
c. Risks Associated with Residuals	• Risk not reduced	• No significant risk based on achieving applicable method/cleanup standards.	• No significant risk based on achieving applicable method/cleanup standards.	• No significant risk based on achieving applicable method/cleanup standards.
Risk Rating	P	G	F	F

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction

Table 5-1

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
EVALUATION OF REMEDIAL ACTION ALTERNATIVES

EVALUATION CRITERIA	REMEDIAL ACTION ALTERNATIVES			
	1 No Action	2* On-Property Wells With Selected Soil Component	3* On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4* On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
6. Benefits				
a. Restores Natural Resources	• No benefit	• Aquifer restored.	• Aquifer restored.	• Aquifer restored.
b. Achieves Productive Reuse of Site	• No changed site conditions.	• Achieves productive reuse.	• Achieves productive reuse.	• Achieves productive reuse.
c. Avoids Cost of Relocation or Provision of Alternate Water Supply	• No alternative water supply required.	• No alternative water supply required.	• No alternative water supply required.	• No alternative water supply required.
d. Avoids Lost Value	• Fails to avoid lost value of site.	• Avoids lost value of site.	• Avoids lost value of site.	• Avoids lost value of site.
Benefits Rating	P	G	G	G
7. Timeliness				
a. Time to Eliminate Uncontrolled Sources	• Much greater than 80 years.	• 6 months to 1 year	• 6 months to 1 year	• 6 months to 1 year
b. Time to Achieve No Significant Risk	• Much greater than 80 years.	• 80 years	• 65 years	• 35 years
Timeliness Rating	P	F	F	G

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

Table 5-1
MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
EVALUATION OF REMEDIAL ACTION ALTERNATIVES

EVALUATION CRITERIA	REMEDIAL ACTION ALTERNATIVES			
	1 No Action	2* On-Property Wells With Selected Soil Component	3* On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4* On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
8. Non-Pecuniary				
a. Aesthetics	• Visual contamination (sheen) at outfall.	• Long term treatment facility on-site at one location. • Trenches for approximately 1,000 feet of discharge piping in wetlands • Potential changes in vegetation over 15,000 square feet of wetlands.	• Long term treatment facility on-site at one location. • Four wells and approximately 3,800 feet of trenches for transmission and discharge piping in wetlands. • Potential change in vegetation over 150,000 square feet of wetlands.	• Long term treatment facility on-site at one location. • Eight wells and approximately 4,000 feet of trenches for transmission and discharge piping in wetlands. • Potential change in vegetation over 830,000 square feet of wetlands.
Non-Pecuniary	F	G	F	F

G = Good, F = Fair, P = Poor

* Alternatives 2, 3, and 4 include excavation of soil in the Eastern Parking Lot and sediment in Outfall Basin 001 with off-site thermal desorption. Soil in Tank Farm and Tank K will be treated in situ with soil vapor extraction.

5.3.1.2 *Reliability*

There is no certainty that cleanup objectives would be achieved in soil and groundwater under the No Action Alternative. Residuals would remain on-site for an indefinite time period with no measures in place to manage or control them. Migration of contamination to another area of the site, or even off site, could occur. Since no remediation or treatment of contamination would occur in this alternative, there would be no emissions or residuals from treatment processes to be concerned with.

In summary, the No Action Alternative provides no certainty of success for site remediation, and site residuals would not be controlled or managed effectively.

5.3.1.3 *Implementability*

The No Action Alternative would not be technically complex since, other than annual monitoring of some of the existing wells on-site, there would be no actions being taken. No operations and maintenance issues are involved, and other than monitoring there would be nothing to integrate with existing facility operations. There would be no need for permits, approval or licenses associated with the implementation of this Alternative. Nor, is this alternative limited by the availability to services, materials, personnel or off-site treatment storage or disposal facilities. Access agreements would be required to allow sampling of monitoring wells located off-property.

In summary, the No Action Alternative would be easy to implement, as no remedial actions would be taken.

5.3.1.4 *Costs*

Under this alternative there would be no costs associated with energy consumption. In addition, no restoration of areas affected by implementation of the alternative would be required. No impacts on natural resources would be expected from this alternative. The only costs associated with implementation of this alternative would be for annual monitoring ($330,000). For costing purposes, it has been assumed that monitoring would consist of annual sampling of wells at 40 locations throughout the site, over an 80 year period, and analyzing the samples for the known site contaminants. (The duration and frequency of this monitoring would be further evaluated during detailed design, and periodically reviewed and revised, if appropriate, during implementation of the alternative.) Table 5-2 details the cost associated with the monitoring effort.

In summary, the No Action Alternative would be the least expensive of the alternatives to implement, since no construction or O&M activity other than site monitoring would take place.

5.3.1.5 Risks

Since the No Action Alternative includes no active measures at the site, there would be no short term risks associated with its implementation.

As described above, the No Action Alternative would not meet the remedial action goals identified in Section 2.2. Given the sources of contamination that would be left on the site in terms of heavily contaminated soils and separate phase product, the site would continue to pose the risks identified by ADL (1991) and summarized in Section 2.1 indefinitely.

In summary, while the No Action Alternative poses no risks to health, safety, public welfare or the environment during implementation, it provides for no reduction in the risks posed by the site. In addition, the nature of the source areas at the site would not allow for a natural reduction in those risks over any foreseeable time period.

5.3.1.6 Benefits

There are no benefits associated with the No Action Alternative. The aquifer would not be restored and site conditions as they relate to contamination would remain unchanged. Any lost value of the site associated with the presence of the contaminants would continue. Because arrangements have already been made with adjacent towns to supplement their water supply systems, arranging for an alternate water supply at this time would not be necessary.

In summary, no benefits would result if the No Action Alternative were implemented.

5.3.1.7 Timeliness

The No Action Alternative does not eliminate uncontrolled sources of oil and hazardous material, nor is it expected to achieve a level of No Significant Risk within a foreseeable period of time.

Table 5-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
GROUNDWATER COMPONENT COST ESTIMATE
ALTERNATIVE 1

Item	Amount
1. Construction Cost	-0-
2. Future Equipment	-0-
3. Annual Operations and Maintenance	-0-
4. Annual Groundwater Monitoring	$20,000
5. Present Worth of Future Equipment	-0-
6. Present Worth of Annual O&M	-0-
7. Present Worth of GW Monitoring [P/A (6%, 80 YRS) = 16.5091]	$330,000
Total Present Worth (1+5+6+7)	$330,000

5.3.1.8 *Non-Pecuniary Issues*

Because no remediation activities would be implemented, the site would remain undisturbed and retain its current appearance. In most instances, this would not be a negative aesthetic impact, because soil and groundwater contamination occurs at depth or is covered by a paved asphalt surface. At one location, Outfall 001, there would be visual evidence of the contamination, in the form of a sheen on surface water and staining of sediments.

In summary, the No Action Alternative would continue to have negative aesthetic impacts at Outfall 001.

5.3.2 Remedial Action Alternative 2 - On-Property Wells Only and Soils Remediation

5.3.2.1 *Effectiveness*

This alternative represents a permanent solution given that uncontrolled sources of oil and hazardous material would be removed through excavation and treatment. In addition, a level of No Significant Risk would be achieved through the implementation of soil excavation and treatment, as well as, groundwater treatment. Background concentrations would be achieved in areas where soils are excavated and backfilled with clean soils from off site. Soils subjected to vapor extraction (Tank K and The Tank Farm areas) would approach background levels in that they would be remediated to concentrations substantially lower than the applicable Method 1 Standard. Groundwater beneath the property and much of the wetland would also approach background levels in that it would be remediated to concentrations substantially lower than the applicable Method 1 Standard.

Alternative 2 would consist of on-site treatment of groundwater (with treated water discharged to the wetlands) and on-site treatment of soil in areas where soil vapor extraction would be implemented. Excavated soil and sediment would be treated at an off-site thermal desorption facility. The granular activated carbon used to polish the treated groundwater and collect off-gases from the air stripper would be shipped off-site for regeneration. Sludges from the precipitation steps in the groundwater treatment system would also be sent off-site to a TSD facility for disposal.

In summary, Alternative 2 would effectively achieve a level of No Significant Risk and approach background levels for soils and groundwater. It would also be effective in that it would involve the treatment of both soil and groundwater on-site.

5.3.2.2 *Reliability*

The certainty of success for achieving the remedial action goals for on-property soil and groundwater is high under this alternative. Remediation technologies would be actively implemented in the on-property area in those areas where soil and groundwater contamination is known to exist. For the same reason, there is a high certainty of success in the area of the discharge for Outfall 001, where contaminated sediments would be excavated and sent off site for thermal desorption, and the excavated area backfilled with clean soil.

In the wetlands area, this alternative offers less certainty of success than Alternative 4 because there is no active control over the capture and removal of contaminants; rather the cleanup objectives are achieved through natural attenuation. The anticipated timeframe of eighty years to meet the cleanup objectives results in greater potential for variations in groundwater flow (such as groundwater withdrawal or pumping by others) than alternatives that would be completed in a shorter timeframe. In addition, the potential for greater uncertainties exists when making predictions over longer timeframes.

No measures are included in this alternative to control or manage residuals in the soils and groundwater after remediation is complete, since it is anticipated that any residuals would be below the applicable cleanup standards, and therefore would pose no significant risk. Residuals from the groundwater treatment system process would be sent off-site for disposal or destruction. For example, sludges from metals precipitation would be sent to a TSD facility for disposal, and granular activated carbon would be sent off-site for regeneration. The gaseous emissions from system components such as the stripping tower, or a soil vapor extraction system, would be passed through granular activated vapor phase carbon or a catalytic oxidizer (Tank K SVE System) for removal/destruction of contaminants prior to discharge to the atmosphere. Treated groundwater would likewise be polished by passing it though liquid phase carbon prior to being discharged to the wetlands.

In summary, there is a reasonably good certainty of success for achieving remedial action goals under Alternative 2. In addition, the alternative includes measures where necessary to control discharges or emissions to the environment.

5.3.2.3 *Implementability*

The implementation of Alternative 2 would not be technically complex, because it would involve known technologies, implemented in a straightforward manner. All soils excavation for treatment, and groundwater recovery and treatment, would be done on the property. There would, however, be approximately 1000 feet of piping off-site for discharge to the wetlands.

In Alternative 2, the excavation would be planned so as to minimize interference with existing facility operations. This would be done by dividing the area to be excavated into small segments which would then be excavated sequentially one after the other. The area previously excavated would be backfilled with clean soil prior to moving on to the next segment. The groundwater treatment system would be placed on the property so as not to interfere with facility operations.

Monitoring of wells would likely be required across the site over the entire length of time to achieve the cleanup objectives (approximately 80 years). The need for O&M for the groundwater treatment system on-property would end when the system shuts down after approximately 20 years. It is anticipated that the soil vapor extraction systems would have achieved their goals earlier (3 years for the Tank K area and 8 years for the Tank Farm area) at which time O&M for those areas would end.

Access agreements would have to be obtained for the construction and operation of the surface discharge pipe which would transport treated groundwater into the wetlands.

Services to operate and maintain the remediation facilities would be readily available since all of the equipment and process units proposed for the remediation system are in common use. Likewise, no problems are anticipated relative to the availability of TSD facilities for disposal of hydroxide sludges or for regeneration of granular activated carbon because none of the contaminants of concern are so toxic or unusual as to be unacceptable at most of the TSD facilities in use today.

The implementation of Alternative 2 would require an Order of Conditions from the North Reading Conservation Commission, and State and Federal wetland permits. These permits would need to address 1) the limited area of drawdown (approximately 15,000 square feet with greater than 0.5 feet of drawdown) expected in the wetlands near the on-property boundary once the extraction wells are turned on, 2) piping across the wetlands, and 3) discharge to the wetlands. In addition, the discharge to surface water would require a NPDES permit.

In summary, aside from the No Action Alternative, Alternative 2 would be the most easily implemented, in terms of complexity, operations and maintenance, access, and permitting.

5.3.2.4 *Cost*

The cost to implement Alternative 2 is estimated in present worth dollars to be $8.3 million. This cost is inclusive of costs for design and construction of the various components of the alternative as well as the costs to operate and maintain it during the approximately 20 years of its operation. Also included in the present worth cost figure are costs associated with annual monitoring of the site for the estimated 80 year cleanup period for the wetlands. (The duration and frequency of this monitoring would be further evaluated during detailed design, and periodically reviewed and revised, if appropriate, during implementation of the alternative.) Tables have been prepared which summarize the major cost components of the remediation program under Alternative 2 (see Tables 5-3, 5-4 and 5-5). The estimated cost associated with energy consumption is included on Tables 5-3 and 5-4 as a separate line item.

It is projected that this alternative would cause drawdown of more than 0.5 feet over an area of approximately 15,000 square feet during operation of the groundwater extraction wells over a period of 20 years. Although this drawdown may alter the wetlands vegetation, it is expected that existing vegetation will recover once the wells are turned off.

In summary, aside from the No Action Alternative, Alternative 2 is the least costly financially, and also in terms of physical impacts to the wetlands.

5.3.2.5 *Risk*

Activities associated with the implementation of Alternative 2 could pose short term risks to workers at the facility and off site receptors. These activities, as well as potential short term risks, are summarized below:

Table 5-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SELECTED SOIL COMPONENT COST ESTIMATE
EXCAVATION/SOIL VAPOR EXTRACTION/OFF-SITE THERMAL DESORPTION

Item	Unit	Unit Cost	Cost*
1. Construction Cost a. Excavation			
i. Eastern Parking Lot	9400 ton	$42/ton	$395,000
ii. Drum Storage Area	1200 ton	$46/ton	55,000
iii. Outfall 001	500 ton	$110/ton	55,000
b. Hauling	11,000 ton	$17.50/ton	193,000
c. Analytical	35 samples	$1,200/sample	42,000
d. Treatment (Off-Site Thermal Desorption)	11,000 ton	$50/ton	550,000
e. Soil Vapor Extraction Systems			
i. Tank Farm			
- Extraction Wells	3 wells	$1,000/well	3,000
- Vacuum Blower	1	$18,000	18,000
- Separator	1	$15,000	15,000
- Heat Exchanger	1	$6,000	6,000
- Vapor Treatment Blower	1	$18,000	18,000
- Utility Trenches	500 feet	$10/foot	5,000
- Piping	500 feet	$20/foot	10,000
- Instrumentation (10%)			8,000
- Electric (13%)			10,000

* Costs are rounded to the nearest thousand

Table 5-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SELECTED SOIL COMPONENT COST ESTIMATE
EXCAVATION/SOIL VAPOR EXTRACTION/OFF-SITE THERMAL DESORPTION

Item	Unit	Unit Cost	Cost*
- Building (26%)			20,000
Subtotal			$113,000
ii. Tank K			
- Extraction Wells	5 wells	$1,000/well	5,000
- Vacuum Blower	1	$14,000	14,000
- Separator	1	$15,000	15,000
- Catalytic Oxidizer	1	$80,000	80,000
- Utility Trenches	500 feet	$10/foot	5,000
- Piping	500 feet	$20/foot	10,000
- Instrumentation (10%)			13,000
- Electric (13%)			17,000
- Building (26%)			34,000
Subtotal			$193,000
Soil Vapor Extraction System Total Cost			$306,000

* Costs are rounded to the nearest thousand

Table 5-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTHREADING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SELECTED SOIL COMPONENT COST ESTIMATE
EXCAVATION/SOIL VAPOR EXTRACTION/OFF-SITE THERMAL DESORPTION

Item	Unit	Unit Cost	Cost*
f. Paving	40,000 SY	$3.25/SY	130,000
Subtotal			1,726,000
Engineering (Design, Construction Management) (20%)			345,000
Contingency (25%)			432,000
Sum of Above			$2,503,000
2. Annual Operations and Maintenance			
a. Tank Farm SVE System			
i. Utilities (55 hp)	425,000 kw. hr	$0.1/kw. hr.	$43,000
ii. Vapor Phase Carbon (15 lb./day)	5,500 lbs.	$4.25/lb.	23,000
iii. Labor	1 hr./day	$40/hr.	15,000
iv. Analytical	24 samples	$250/sample	6,000
v. Maintenance (6% of Construction Cost)			10,000
Subtotal			$97,000/YR
b. Tank K SVE System			
i. Utilities			
– Electric (25 hp)	193,000 kw. hr.	$0.1/kw. hr.	19,000
– Natural Gas (3.6 scfm)	1,900 - 1,000 ft^3	$10.50/1,000scf	20,000
ii. Labor	1 hr./day	$40/hr.	15,000

* Costs are rounded to the nearest thousand

Table 5-3

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

SELECTED SOIL COMPONENT COST ESTIMATE
EXCAVATION/SOIL VAPOR EXTRACTION/OFF-SITE THERMAL DESORPTION

Item	Unit	Unit Cost	Cost*
iii. Analytical	24 samples	$250/sample	6,000
iv. Maintenance (6% of Construction Cost)			17,000
Subtotal			77,000/YR
Sum of Above			174,000/YR
3. Present Worth of O&M a. Tank Farm SVE System			
P/A (6%, 8 yrs) = 6.2098			$602,000
b. Tank K SVE System			
P/A (6%, 3 yrs) = 2.6730			206,000
Total			808,000
4. Total Present Worth (Construction Cost and O&M)			3,311,000

* Costs are rounded to the nearest thousand

Table 5-4

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS

REMEDIAL ACTION PLAN

GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE

ALTERNATIVE 2

Item	Amount*
1. Construction Cost	
a. Groundwater Treatment Plant	
i. Oil/Water Separator	$25,000
ii. Equalization/Precipitation/Sludge Handling	133,000
iii. Product Collection Tank	3,000
iv. Neutralization	40,000
v. Filtration	93,000
vi. Air Stripper	48,000
vii. Preheater/Blower	13,000
viii. Polishing GAC Unit	85,000
Purchased Equipment & Installation (PE&I)	440,000
Instrumentation (10% PE&I)	44,000
Piping (21% PE&I)	92,000
Electrical (13% PE&I)	57,000
Building (26% PE&I)	114,000
Groundwater Treatment Plant Subtotal	747,000
b. Groundwater Collection/Discharge System (see Table 5-5)	490,000
Groundwater Treatment/Collection Subtotal	1,237,000
Engineering (Design, Construction Management) (20%)	247,000
Contingency (25%)	309,000
Total	$1,793,000

* Cost is rounded to the nearest thousand.

Table 5-4

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE
ALTERNATIVE 2

Item	Amount*
2. Future Equipment	-0-
3. Annual Operations and Maintenance	
a. Utilities (30HP, $0.1/ kw•hr)	$ 23,000
b. Labor (2 hr/d, $40/hr)	29,000
c. Maintenance	64,000
d. Chemicals (140 ton, $55/ton)	8,000
e. Vapor Phase Carbon (40 lb/d, $4.25/lb)	62,000
f. Liquid Phase Carbon (10 lb/d, $3.50/lb)	13,000
g. Analytical ($2500/mo)	30,000
h. Sludge Disposal (130 drums, $150/drum)	20,000
i. Product Disposal (500 gal, $5/gal)	3,000
Total	$ 252,000
4. Annual Groundwater Monitoring	20,000/YR
5. Present Worth of Future Equipment	-0-
6. Present Worth of Annual O&M [P/A (6%, 20 YRS) = 11.4699]	2,890,000
7. Present Worth of GW Monitoring [P/A (6%, 80 YRS) = 16.5091]	330,000
Total Present Worth (1+5+6+7)	$5,013,000

* Cost is rounded to the nearest thousand.

Table 5-5

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER COLLECTION/DISCHARGE SYSTEM CONSTRUCTION COST ESTIMATE -- ALTERNATIVE 2

Description	Unit	Unit Cost	Cost*
1. Collection			
A. Overburden Wells	7	$3,500	$25,000
B. Bedrock Wells	10	$9,000	$90,000
C. Utility Trenches	3,600 ft	$20.00/ft	$72,000
D. Piping	3,600 ft	$17.50/ft	$63,000
E. Overburden Well Pumps	7	$9,250	$65,000
F. Bedrock Well Pumps	10	$7,000	$70,000
		Subtotal	***$385,000***
2. Discharge			
A. Utility Trenches	1,800 ft	$23.00/ft	$41,000
B. Piping	1,800 ft	$18.75/ft	$34,000
C. Easement	3	$10,000	$30,000
		Subtotal	***$105,000***
		Total	***$490,000***

* Cost is rounded to the nearest thousand.

1. This alternative would involve the excavation of soil from the Eastern Parking Lot, Drum Storage Area and sediment from Outfall 001. This soil would be stockpiled briefly on the site before transport off-site to a treatment facility. This excavation is expected to take place over a 6-12 month period.

   This activity may result in the generation of releases of particulates and vapors during excavation and during handling of the soil and the separate phase product. These releases would likely be limited to the areal extent of the work area at any particular time and exposures limited to facility workers in that area. These exposures could occur over different areas in the excavation area over the 6-12 month period. In areas where product recovery would occur, each staged area would be open for the minimal time to achieve product recovery. These open excavations may also pose a risk to public safety. In addition, the handling of separate phase product could result in a release of that product to localized areas. The above releases and potential risks could be largely controlled through good work practices, such as limiting the area of open excavation, covering the excavation when work is not being conducted, covering stockpiled soils, etc. The Remedy Implementation Plan should include measures to be taken to control releases from these locations if monitoring indicates they are warranted. If possible, access to active work areas by facility workers should be controlled.

2. The installation of vapor extraction systems in the Tank Farm and Tank K area would include the installation of wells, the excavation of trenches for piping, and the construction of a treatment facility for each of the two locations. The associated excavations would involve some soil removal and handling, but the volumes and time involved would be much shorter than for the soil excavation in other site locations. No short term exposures or risks are expected from the construction of the treatment facility. Therefore, the risks associated with this activity are expected to be insignificant.

3. This alternative includes the off-site treatment of excavated soil and the off-site incineration of drummed separate phase product that is recovered. This activity involves transportation to the off-site facility as needed over the 6-12 month period. Releases may occur during the transport of contaminated soils, potentially resulting in exposures to off-site receptors through inhalation. These exposures can largely be controlled through measures taken to control releases during transportation (e.g., polyethylene liner to line the inside of truck bed and a tarp pulled over the top of the soils to prevent contact with precipitation and reduce volatilization of contaminants from soil).

4. Groundwater recovery and treatment activities would include the installation of wells on the property, the excavation of trenches for piping and the construction of the treatment plant. The excavations would involve some soil removal and handling. Most of these trenches would be in areas where soil contamination above cleanup levels has not been identified. The excavation of the Eastern Parking Lot would be completed before the piping for the groundwater treatment system is installed in that area. Therefore, the risks associated with this activity are expected to be insignificant.

The operation of Alternative 2 could result in some releases of oil and hazardous materials from treatment systems during the period of operation. In addition, the groundwater pump and treat and soil vapor extraction systems would take an extended period of time to achieve the cleanup objectives, during which the potential for exposure will still exist.

It is estimated that the vapor extraction systems would operate in the Tank Farm area for approximately 8 years and in the Tank K area for approximately 3 years (See Section 4.4). During these periods, off-gases from the systems in the Tank Farm and the Tank K area would be treated by vapor phase carbon and catalytic oxidation, respectively. These control systems would achieve the control of air emissions from remedial systems required by the MCP (310 CMR 40.0040), thus minimizing exposures to facility workers and any nearby receptors.

It is estimated that the groundwater treatment system will operate for approximately 20 years (See Section 4.7). During this period some emissions from this system can be expected. However, off-gases from the air stripper would be treated by vapor phase carbon. This control system would achieve the control of air emissions from remedial systems required by the MCP (310 CMR 40.0040), thus minimizing exposures to facility workers and any nearby receptors.

The above treatment systems would generate spent carbon, and the groundwater treatment system would also generate sludge that would be disposed of off-site. Their transportation would occur sporadically over the time of treatment. Releases from the transportation of these materials can generally be controlled by measures taken to control releases during transportation.

The implementation of Alternative 2 is expected to pose a risk to the wetland as a result of the drawdown of the water level, as described in Section 4.6.3. Modeling indicates that drawdown would be equal to or greater than 0.5 feet over 15,000 square feet of the wetlands for 20 years. This drawdown can be expected to alter the wetlands vegetation and habitat within this area. It is possible, however, that some recovery of original vegetation and habitats could occur after implementation is complete.

It should be noted that Alternative 2 will require approximately 20 years to meet remedial objectives on the property, and 80 years in the wetlands, based on modeled cleanup time for bedrock. During this time, the groundwater on the property poses no significant risk. As discussed in Section 2.3.1, because the Ipswich River Basin has been identified as a deficit basin (highly stressed aquifer) by the Department of Environmental Management and U.S. Geological Survey, the future development of this portion of the aquifer for drinking water purposes over this period is not anticipated.

In addition, the groundwater in and leaving the wetlands poses no significant risk for the following reasons. The risk of vapors migrating into buildings located at the eastern end of the wetlands along Concord Street is insignificant based on a review of all groundwater analytical data for sampling of wells in the wetlands. This data showed that no compounds have been detected at concentrations (above the laboratory method detection limit) which exceed GW-2 standards (i.e., the standards which are protective of vapor migration to indoor air). Similarly, there is no significant risk to aquatic life posed by the discharge of groundwater to the Ipswich River given that no GW-3 standards have been

Table 5-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTHREADING, MASSACHUSETTS
REMEDIAL ACTION PLAN
GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE
ALTERNATIVE 3

		Item	Amount*
2.	**Future Equipment**		
	a.	Replacement of Treatment Plant @ Year 20 (Q=90 gpm)	1,462,000
	b.	Replacement of Treatment Plant @ Year 40 (Q=90 gpm)	1,462,000
		Total	2,924,000
3.	**Annual Operations and Maintenance (155 gpm)**		
	a.	Utilities (40 HP, 0.1/kw•hr)	$ 31,000
	b.	Labor (3 hr/d, $40/hr)	44,000
	c.	Maintenance	115,000
	d.	Chemicals (180 ton, $55/ton)	10,000
	e.	Vapor Phase Carbon (55 lb/d, $4.25/lb)	85,000
	f.	Liquid Phase Carbon (20 lb/d, $3.50/lb)	26,000
	g.	Analytical ($2500/mo)	30,000
	h.	Sludge Disposal (210 drums, $150/drum)	32,000
	i.	Product Disposal (500 gal., $5/gal)	3,000
		Total	$ 376,000**
4.	**Annual Groundwater Monitoring**		20,000/YR
5.	**Present Worth of Future Equipment**		
	a.	Replacement of Treatment Plant @ Year 20 (P/F = .3118)	456,000
	b.	Replacement of Treatment Plant @ Year 40 (P/F = .0972)	142,000
		Total	598,000

* Costs are rounded to the nearest thousand.
** The O&M cost for 90 gpm treatment facility is estimated to be 75% of the 155 gpm facility or $282,000.

Table 5-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE
ALTERNATIVE 3

Item	Amount*
6. Present Worth of Annual O&M	
a. O&M for 155 gpm facility (0-20 yrs) [P/A (6%, 20 yrs) = 11.4699]	4,313,000
b. O&M for 90 gpm facility (20-65 yrs) [P/A (6%,65 yrs) - P/A (6%, 20 yrs) = 4.8192]	1,359,000
	5,672,000
7. Present Worth of GW Monitoring [P/A (6%,65 yrs) = 16.2891]	326,000
Total Present Worth (1+5+6+7)	$10,005,000

* Costs are rounded to the nearest thousand.
** The O&M cost for 90 gpm treatment facility is estimated to be 75% of the 155 gpm facility or $282,000.

Table 5-7

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER COLLECTION/DISCHARGE SYSTEM CONSTRUCTION COST ESTIMATE -- ALTERNATIVE 3

Description	Unit	Unit Cost	Cost*
1. Collection (On-Property)			
A. Overburden Wells	7	$3,500	$25,000
B. Bedrock Wells	10	$9,000	$90,000
C. Utility Trenches	3,600 ft	$20.00/ft	$72,000
D. Piping (Secondary Containment)	3,600 ft	$17.50/ft	$63,000
E. Overburden Well Pumps	7	$9,250	$65,000
F. Bedrock Well Pumps	10	$7,000	$70,000
		Subtotal	***$385,000***
2. Collection (Wetlands)			
A. Overburden Wells	1	$10,000	$10,000
B. Bedrock Wells	3	$12,500	$38,000
C. Utility Trenches	4,600/ft	$10.75	$49,000
D. Piping (Secondary Containment)	3,950/ft	$36.75	$145,000
E. Overburden Well Pumps	1	$4,000	$4,000
F. Bedrock Well Pumps	3	$1,500	$5,000
G. Easement	3	$10,000	$30,000

* Costs are rounded to the nearest thousand

Table 5-7

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER COLLECTION/DISCHARGE SYSTEM CONSTRUCTION COST ESTIMATE -- ALTERNATIVE 3

Description	Unit	Unit Cost	Cost*
H. Pump Test	1	$275,000	$275,000
		Subtotal	***$556,000***
3. Discharge			
A. Utility Trenches (Part of Wetlands Collection)	-		-
B. Piping	3,250 ft	$20/ft	$65,000
C. Easement	1	$10,000	$10,000
		Subtotal	***$75,000***
		Total	***$1,016,000***

* Costs are rounded to the nearest thousand

for the installation of the piping to the treatment system. These activities would result in temporary damage to the wetlands from the machinery required and from the trenches themselves. It is expected that this damage would be temporary, if the construction activities minimize this damage to the extent possible. There could, however, be long term impacts due to operations and maintenance of these wells, and possibly the need for a road to facilitate these activities.

The potential risks related to the operation of the vapor extraction systems are described in Alternative 2. The groundwater treatment system in Alternative 3. is expected to operate for a much longer period (65 years). Therefore, while the air emissions from this treatment system are controlled, they would occur over a longer period as compared to Alternative 2. Similarly, the transport of sludge from the groundwater treatment system would occur over a longer period.

The risks to the wetland associated with the drawdown of the water level are greater for Alternative 3, as compared to Alternative 2. Modeling indicates that an estimated 150,000 square feet of wetlands would experience a drawdown of at least 0.5 feet over the 65 year period of operation. This drawdown can be expected to alter the wetlands vegetation and habitat within this area. Given the size of the area, any wetlands recovery would probably be a lengthy process.

According to the modeling results, Alternative 3 takes a somewhat shorter time to achieve remedial objectives (65 years) as compared to Alternative 2 (80 years). Potential risks (during this time period) associated with groundwater beneath the wetlands, or groundwater leaving the wetlands (with respect to impact on drinking water supplies, indoor air quality, or surface water quality as it effects aquatic life or potential water supplies) are considered insignificant for the same reasons described in Alternative 2.

The implementation of Alternative 3 is intended to achieve a level of No Significant Risk. The achievement of the cleanup objectives identified in Section 2.2 will ensure that any residuals at the site do not pose significant risks to health, safety, public welfare or the environment.

In summary, the implementation of Alternative 3 will achieve a level of No Significant Risk. During implementation, short term risks of the greatest concern (soil excavation and separate phase product removal) are the same as those identified for Alternative 2. In addition, Alternative 3 poses short term risks to the wetland during construction of the wells and piping, and long-term risks due to potential construction of a road and drawdown of the water table during operations. Risks posed by oil and hazardous materials at or from the site during the time required for remediation are not significant because use of the aquifer for drinking water purposes is not anticipated. In addition, other potential risks (to indoor air, surface water quality, and existing supply wells) are considered insignificant. Alternative 3 also poses greater risk to the wetlands associated with drawdown of the water table (compared to Alternative 2) because it affects a much larger area for a much longer timeframe.

5.3.3.6 *Benefits*

Alternative 3 would ensure the restoration of the site's groundwater aquifer and allow for the productive reuse of the site. Any value of the site which may have been lost because of the contamination would be avoided upon completion of site remediation under Alternative 3. Alternative 3 is identical to Alternatives 2 and 4 with regard to the benefits resulting from its implementation.

5.3.3.7 *Timeliness*

The implementation of Alternative 3 would eliminate uncontrolled sources of oil and hazardous materials within 12 months. All soil remediation would be completed within 8 years. It is projected that cleanup objectives for groundwater on property will be achieved in approximately 20 years, and for the wetlands in approximately 65 years (compared to 80 years for Alternative 2 and 35 years for Alternative 4).

5.3.3.8 *Non-Pecuniary Issues*

A groundwater treatment system would be on site for approximately 65 years under this alternative, but it will be constructed in a little used area of the site, near the existing basketball courts in the northeast section of the paved area. The vapor extraction systems at Tank K and Tank Farm would operate for only 3 and 8 years, respectively, and would be relatively unobtrusive. Their appearance would blend in with the industrial facilities currently existing at the on-property area.

Aesthetics of the wetlands would be affected by the construction of approximately 3,800 feet of trenching for transmission and discharge piping. In addition, changes to the

Table 5-6

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS

REMEDIAL ACTION PLAN

GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE

ALTERNATIVE 3

Item	Amount*
1. Construction Cost	
a. Groundwater Pretreatment System	
i. Oil/Water Separator	$25,000
ii. Equalization/Precipitation/Sludge Handling	175,000
iii. Product Collection Tank	3,000
iv. Neutralization	53,000
v. Filtration	158,000
vi. Air Stripper	133,000
vii. Preheater/Blower	28,000
viii. Polishing GAC Unit	210,000
Purchased Equipment & Installation (PE&I)	785,000
Instrumentation (10% PE&I)	79,000
Piping (21% PE&I)	165,000
Electrical (13% PE&I)	102,000
Building (26% PE&I)	204,000
Groundwater Treatment Plant Total (155 gpm)	1,335,000
b. Groundwater Collection System (see Table 5-7)	1,016,000
Groundwater Treatment/Collection Subtotal	2,351,000
Engineering (Design, Construction Management) (20%)	470,000
Contingency (25%)	588,000
Total	$3,409,000

* Costs are rounded to the nearest thousand.

** The O&M cost for 90 gpm treatment facility is estimated to be 75% of the 155 gpm facility or $282,000.

exceeded in any wells in the wetlands. The risk to the Ipswich River as a potential source of drinking water is also insignificant because this portion of the River is a Class B surface water according to Massachusetts Water Quality Standards 314 CMR 5.06, and therefore any use of the River as a public water supply would require appropriate treatment.

The risk associated with use of groundwater as a potential water supply south of the Ipswich river is also considered insignificant because this area is part of the deficit basin, and therefore as described above, future development of the aquifer for drinking water purposes is not anticipated. Potential risks associated with groundwater leaving the wetlands and being drawn into the Town of Reading 82-20 and Town Forest wells are also insignificant, because treatment of VOC contamination in these wells has already been addressed by the installation in 1991 of a water supply treatment system upgrade that was funded by GE Aerospace.

The implementation of Alternative 2 is intended to achieve a level of No Significant Risk. The achievement of the applicable cleanup levels or cleanup objectives identified in Section 2.2 will ensure that any residuals at the site do not pose significant risks to health, safety, public welfare or the environment.

In summary, the implementation of Alternative 2 would achieve a level of No Significant Risk. During implementation, risks of greatest concern would be associated with the soil excavation and separate phase product removal. Risks posed during operation of the treatment systems would be controlled to the extent feasible. Risks posed by oil and hazardous materials at or from the site during the time required for remediation are not significant because use of the aquifer for drinking water purposes is not anticipated. In addition, other potential risks (to indoor air, surface water quality, and existing supply wells) are considered insignificant. Alternative 2 also poses the least risk to the wetlands associated with drawdown of the water table because it affects the smallest area over the shortest timeframe compared to the other alternatives which actively promote remediation.

5.3.2.6 Benefits

Alternative 2 would ensure the restoration of the site's groundwater aquifer and allow for productive reuse of the site. Any value of the site which may have been lost because of the contamination would be avoided upon completion of site remediation under Alternative 2.

5.3.2.7 *Timeliness*

The implementation of Alternative 2 would eliminate uncontrolled sources of oil and hazardous materials within 12 months. All soil remediation would be completed within in 8 years. It is projected that cleanup objectives for groundwater on property would be achieved in approximately 20 years and for the wetlands in approximately 80 years.

5.3.2.8 *Non-Pecuniary Issues*

A groundwater treatment system would be on site for approximately 20 years under this alternative, but it would be constructed in a little used area of the site, near the existing basketball courts in the northeast section of the paved area. The vapor extraction systems at Tank K and Tank Farm would operate for only 3 and 8 years, respectively, and would be relatively unobtrusive. Their appearance would blend in with the industrial facilities currently existing at the on-property area.

Aesthetics of the wetlands would be affected by the construction of approximately 1000 feet of piping for discharge of treated water. In addition, changes to the wetlands vegetation would occur in the approximately 15,000 square feet area affected by drawdown caused by operation of the groundwater extraction wells on-property for the 20 year period. This area, however, is relatively small (approximately 0.5%) compared to the size and extent of the wetland, and the vegetation is anticipated to recover once the extraction wells are shut down.

In summary, Alternative 2 has the least negative effects on aesthetic values of any of the alternatives which actively promote site remediation.

5.3.3 Remedial Action Alternative 3 - On-property Wells and Wells at Eastern End of Wetlands, with Soil Remediation

5.3.3.1 *Effectiveness*

This alternative represents a permanent solution given that uncontrolled sources of oil would be removed through excavation and treatment. In addition, a level of No Significant Risk would be achieved through the implementation of soil excavation and treatment, as well as groundwater treatment. Background concentrations would be achieved in areas where soils are excavated and backfilled with clean soils from off site. Soils subjected to vapor extraction (Tank K and The Tank Farm areas) would approach background levels in that they would be remediated to concentrations substantially lower than the applicable Method 1 Standard. Groundwater beneath the property and much of the wetland will also approach background levels in that it would be remediated to concentrations substantially lower than the applicable Method 1 Standard.

Alternative 3 would consist of on-site treatment of groundwater (with treated water discharged to the wetlands) and on-site treatment of soil in areas where soil vapor extraction would be implemented. Soil and sediment that would be excavated would be treated at an off-site thermal desorption facility. The granular activated carbon used to polish the treated groundwater and collect off-gases from the air stripper would be shipped off-site for regeneration. Sludges from the precipitation steps in the groundwater treatment system will also be sent off-site to a TSD facility for disposal.

In summary, Alternative 3 would effectively achieve a level of No Significant Risk and approach background levels for soil and groundwater. It also involved the treatment of both soil and groundwater on-site.

5.3.3.2 *Reliability*

The certainty of success for achieving the remedial action goals for on-property soils and on-property groundwater is high under this alternative. Remediation technologies would be actively implemented in the on-property area in those areas where soil and groundwater contamination is known to exist. For the same reason, there is a high certainty of success in the area of the discharge for Outfall 001, where contaminated sediments would be excavated and sent off site for thermal desorption, and the excavated area backfilled with clean soil.

In the wetlands area, this alternative offers less certainty of success than Alternative 4 since the cleanup objectives under the wetlands are achieved primarily through natural attenuation. The anticipated timeframe of sixty-five years to meet the cleanup objectives results in greater potential for variations in groundwater flow (such as groundwater withdrawal or pumping by others) than alternatives that would be completed in a shorter timeframe. In addition, the potential for greater uncertainties exists when making predictions over longer timeframes.

The purpose of the wells at the eastern end of the wetlands would be to capture and remediate groundwater as it exits the wetlands. These wells would have little effect on remediating groundwater beneath the wetland, but are placed there to address potential downgradient receptors. As such, these additional wells at the eastern end of the wetlands do not appear to contribute to the overall reliability of the remediation in Alternative 3.

No measures are included in this alternative to control or manage residuals in the soils and groundwater after remediation is complete, since it is anticipated that any residual remaining would be below the applicable cleanup standards, and therefore would pose no significant risk. Residuals from the groundwater treatment system process would be sent off-site for disposal or destruction. For example, sludges from metals precipitation would be sent to a TSD facility for disposal, and granular activated carbon would be sent off-site for regeneration. The gaseous emissions from system components such as the stripping tower, or a soil vapor extraction system, would be passed through granular activated vapor phase carbon or a catalytic oxidizer (Tank K SVE System) for removal/destruction of contaminants prior to discharge to the atmosphere. Treated groundwater would likewise be polished by passing it though liquid phase carbon prior to being discharged to the wetlands.

In summary, Alternative 3 is comparable to Alternative 2 relative to certainty of success in achieving cleanup objectives for site soils and groundwater and control of residuals and discharges to the environment.

5.3.3.3 *Implementability*

Alternative 3 is somewhat more technically complex than Alternative 2 because it involves the construction of wells and piping in the wetlands with transmission of pumped well water across the wetlands to the on-property groundwater treatment system approximately 3,000 feet away. These off property wells would have to be operated and monitored for approximately 65 years, even though the on-property wells would be shut down after approximately 20 years. The size of the groundwater treatment system would be 155 gallons per minute, significantly larger than the 65 gallon per minute system called for under Alternative 2. This larger system would produce larger volumes of sludge and contaminated granular activated carbon, thus requiring more frequent servicing to maintain the facility. This additional servicing would make it slightly more difficult to integrate the groundwater treatment component of the alternative into the ongoing operations of the existing facility operations. In addition, integration with facility operations would be required over a much longer timeframe compared to Alternative 2 (i.e., 65 years versus 20 years).

The monitoring of wells across the site would likely be required over the entire length of time to reach the cleanup objectives (approximately 65 years) as opposed to the 80 year period for Alternative 2. The Operations and Maintenance Activities associated with the groundwater treatment system would also extend to the 65 year period (as opposed to approximately 20 years for Alternative 2). The soil vapor extraction systems would achieve their goals in the same time frame as for Alternative 2 (3 years for the Tank K area and 8 years for the Tank Farm area) at which time O&M for those areas will end.

Access agreements would have to be obtained for the construction and operation of the piping and recovery wells in the wetlands. It appears that access agreements would be required for four properties.

Services to operate and maintain the remediation facilities would be readily available since all of the equipment and process units proposed for the remediation system are in common use. Likewise no problems are anticipated relative to the availability of TSD facilities for disposal of hydroxide sludges or regeneration of granular activated carbon because none of the contaminants of concern are so toxic or unusual as to be unacceptable at most of the TSD facilities in use today.

The implementation of Alternative 3 would require an Order of Conditions from both the North Reading Conservation Commission and the Reading Conservation Commission, and State and Federal wetland permits. These permits would need to address 1) the area of drawdown (approximately 150,000 square feet with greater than 0.5 feet of drawdown) expected in the wetlands, 2) piping across the wetlands, and 3) discharge to the wetlands. In addition, the discharge to surface water would require a NPDES permit. Given that one of the conditions for approval of a Federal permit for a project of this size is whether another feasible alternative exists (which would have less impact on the wetlands), it is uncertain whether a Federal permit could be obtained for this Alternative.

In summary, Alternative 3 would be technically more complex than Alternative 2 because of increased construction in the wetland area and the need to gain access to and operate a collection system in the wetlands. Operation of the groundwater treatment system will require more attention over a longer period of time (65 years) requiring greater integration with existing facility operations than Alternative 2. Obtaining a Federal wetlands permit may not be possible under Alternative 3.

5.3.3.4 Cost

The cost to implement Alternative 3 is estimated in present worth dollars to be $13.3 million. This cost is inclusive of costs for design and construction of the various components of the alternative as well as the costs to operate and maintain it during the approximately 65 years of its operation. Also included in the present worth cost figure are costs associated with equipment replacement during the operational period, and costs associated with annual monitoring of the site for the expected 65 year cleanup period for the wetlands. (The duration and frequency of this monitoring would be further evaluated during detailed design, and periodically reviewed and revised, if appropriate, during implementation of the alternative.) Tables have been prepared which summarize the major cost components of the remediation program under Alternative 3 (see Tables 5-6 and 5-7, and refer to Table 5-3 for the soils component). The estimated cost associated with energy consumption is included on cost Table 5-6 as a separate line item.

It is projected that this alternative would cause drawdown of more than 0.5 feet over an area of approximately 150,000 square feet during operation of the groundwater extraction wells over a period of 65 years. This larger area and longer time frame will entail a greater impact on the wetlands in this area.

In summary, the financial cost of Alternative 3 falls between that of Alternative 2 and Alternative 4. Similarly, Alternative 3 would result in greater impacts on the wetlands than Alternative 2 because it affects a larger area of wetland through drawdown, but not as much as Alternative 4.

5.3.3.5 Risk

The activities associated with Alternative 3 that could pose short term risks to facility workers and off site receptors are similar to those described for Alternative 2. The on-property soil and sediment and groundwater activities and potential risks are the same for Alternative 3 as for Alternative 2. The major difference between these Alternatives is that the groundwater recovery system in Alternative 3 includes a set of groundwater wells installed at the eastern end of the wetlands. Trenches would be dug across the wetlands

wetlands vegetation will occur in approximately 150,000 square feet area affected by drawdown caused by operation of the groundwater extraction wells (approximately 5% of the total wetland area). The 65 year timeframe for this drawdown would make the recovery of wetlands vegetation more difficult after the wells are turned off.

In summary, Alternative 3 has a greater effect on aesthetic values than Alternative 2 as a result of an increased area of impact in the wetlands and the longer timeframe for operation of the on-site groundwater treatment system.

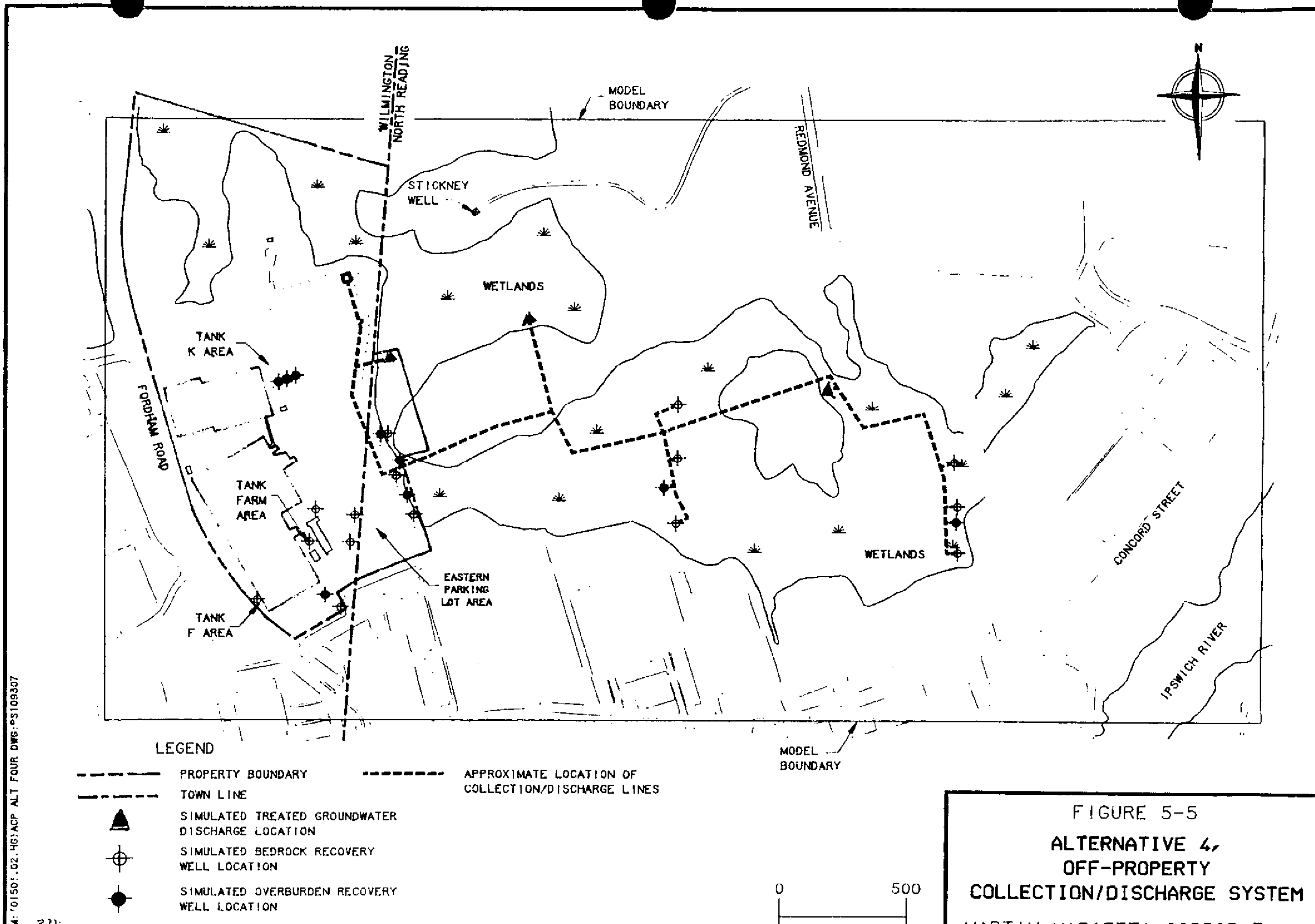
5.3.4 Remedial Action Alternative 4 - On-property Wells and Wells at Middle and Eastern End of Wetlands, With Soils Remediation

5.3.4.1 Effectiveness

This alternative represents a permanent solution given that uncontrolled sources of oil would be removed through excavation and treatment. In addition, a level of No Significant Risk would be achieved through the implementation of soil excavation and treatment, as well as groundwater treatment. Background concentrations would be achieved in areas where soils are excavated and backfilled with clean soils from off site. Soils subjected to vapor extraction (Tank K and The Tank Farm areas) would approach background levels in that they would achieve the cleanup objectives which are lower than the applicable Method 1 Standard. Groundwater beneath the property and much of the site will also approach background levels in that it would be remediated to concentrations substantially lower than the applicable standards for much of the site.

Alternative 4 would consist of on-site treatment of groundwater (with treated water discharged to the wetlands) and on-site treatment of soil in areas where soil vapor extraction would be implemented. Soil and sediment that would be excavated would be treated at an off-site thermal desorption facility. The granular activated carbon used to polish the treated groundwater and collect off-gases from the stripper would be shipped off-site for regeneration. Sludges from the precipitation steps in the groundwater treatment system will also be sent to a TSD facility for disposal.

In summary, Alternative 4 would effectively achieve a level of No Significant Risk and approach background levels for soil and groundwater. It also involves the treatment of soil and groundwater on-site.



WehranEnviroTech
Wehran Engineering Corporation

FIGURE 5-5

ALTERNATIVE 4, OFF-PROPERTY COLLECTION/DISCHARGE SYSTEM

MARTIN MARIETTA CORPORATION
FORDHAM ROAD/CONCORD STREET AREA
WILMINGTON/NO READING, MASSACHUSETTS

10/05 QCM:"0150I.02.HG:ACP ALT FOUR DWG:PS109307

5.3.4.2 *Reliability*

The certainty of success for achieving the remedial action goals for on-property soils and on-property groundwater is high under this alternative. Remediation technologies would be actively implemented in the on-property area in those areas where soil and groundwater contamination is known to exist. For the same reason, there is a high certainty of success in the area of the discharge for Outfall 001, where contaminated sediments would be excavated and sent off site for thermal desorption, and the excavated area backfilled with clean soil.

In the wetlands area this alternative offers a higher certainty of success than the other alternatives since this alternative involves the removal and treatment of contaminated groundwater from the wetlands through the addition of wells placed at strategic locations to accelerate the achievement of cleanup objectives for groundwater beneath the wetlands. These wells in the wetlands would provide partial control over the capture and removal of contaminants from groundwater. By reducing the estimated cleanup time in the wetlands to 35 years, there would be less chance for external variables in flow (such as pumping or withdrawal by others) than alternatives which require a longer timeframe. In addition, there would be fewer uncertainties in making predictions over a shorter timeframe.

No measures are included in this alternative to control or manage residuals in the soils and groundwater after remediation is complete since it is anticipated that any residual remaining would be below the applicable cleanup standards, and therefore would pose no significant risk. Residuals from the groundwater treatment system process would be sent off-site for disposal or destruction. For example, sludges from metals precipitation would be sent to a TSD facility for disposal, and granular activated carbon would be sent off-site for regeneration. The gaseous emissions from system components such as stripping tower, or a soil vapor extraction system, would be passed through granular activated vapor phase carbon or a catalytic oxidizer (Tank K SVE System) for removal/destruction of contaminants prior to discharge to the atmosphere. Treated groundwater would likewise be polished by passing it though liquid phase carbon prior to being discharged to the wetlands.

In summary, Alternative 4 offers a slightly higher certainty of success in achieving cleanup objectives for off-property groundwater compared to Alternatives 2 and 3. The control of residuals and discharges to the environment under Alternative 4 is comparable to Alternatives 2 and 3.

5.3.4.3 *Implementability*

Alternative 4 is more technically complex than Alternatives 2 and 3 because of the increased number of wells in the wetlands and the associated construction effort to install these wells and the trenches for transmission and discharge piping (approximately 4,000 ft) connecting them to the on-property groundwater treatment system. These off-property wells would have to be operated for approximately 35 years, even though the on-property wells would be shut down after 20 years. The size of the groundwater treatment system would be 230 gallons per minute, making it the largest of the systems called for in the alternatives being considered. The system would also produce the greatest volumes of sludge and contaminated activated carbon, thus requiring the most service and attention of the alternatives, and making it the most difficult to integrate into existing facility operations. However, the groundwater treatment system would only have to be integrated with facility operations for approximately 35 years, compared to 65 years under Alternative 3.

The monitoring of wells across the site would likely be required over the entire length of time to reach the cleanup objectives (approximately 35 years as opposed to 80 years for Alternative 2 and 65 years for Alternative 3). The O&M for the groundwater treatment system would also extend over a 35 year period (as opposed to 20 years for Alternative 2 and 65 years for Alternative 3). The soil vapor extraction systems would achieve their goals in the same timeframe as for Alternatives 2 and 3 (3 years for the Tank K area and 8 years for the Tank Farm area) at which time O&M for those areas will end.

Access agreements would have to be obtained for the construction and operation of the piping and recovery wells in the wetlands. Because of the large number of properties affected, a considerable effort will be required to obtain the agreements.

The implementation of Alternative 4 would require an Order of Conditions from both the North Reading Conservation Commission and the Reading Conservation Commission, and State and Federal wetland permits. These permits would need to address 1) the area of drawdown (approximately 830,000 square feet with greater than 0.5 feet of drawdown) expected in the wetlands, 2) piping across the wetlands, and 3) discharge to the wetlands. In addition, the discharge to surface water would require a NPDES permit. Given that one of the conditions for approval of a Federal permit for a project of this size is whether another feasible alternative exists (which would have less impact on the wetlands), it is uncertain whether a Federal permit could be obtained for this Alternative.

Services to operate and maintain the remediation facilities would be readily available since all of the equipment and process units proposed for the remediation system are in common use. Likewise no problems are anticipated relative to the availability of TSD facilities for disposal of hydroxide sludges or regeneration of granular activated carbon because none of the contaminants of concern are so toxic or unusual as to be unacceptable at any of the TSD facilities in use today.

In summary, Alternative 4 would be technically more complex than Alternatives 2 and 3 because of the increased construction in the wetland area and the need to gain access to more properties to operate a collection system in the wetlands. Alternative 4 would also need the most attention during operation because of the larger volume of sludge, and other process residuals produced by the groundwater treatment system. Alternative 4 will require longer integration with existing facility operations (35 years) compared to Alternative 2 (20 years), but less than Alternative 3 (65 years).

5.3.4.4 Cost

The cost to implement Alternative 4 is estimated in present worth dollars to be $13.7 million. This cost is inclusive of costs for design and construction of the various components of the alternative as well as the costs to operate and maintain it during the approximately 35 years of its operation. (The duration and frequency of this monitoring would be further evaluated during detailed design, and periodically reviewed and revised, if appropriate, during implementation of the alternative.) Also included in the present worth cost figure are costs associated with equipment replacement during the operational period, and costs associated with annual monitoring of the site for the expected 35 year cleanup period for the wetlands. Tables have been prepared which summarize the major cost components of the remediation program under Alternative 4 (see Tables 5-8 and 5-9, and Table 5-3 for the soil component). The estimated cost associated with energy consumption is included on cost Table 5-8 as a separate line item.

It is projected that this alternative would cause drawdown of more than 0.5 feet over an area of approximately 830,000 sf during operation of the on-property groundwater extraction wells over a period of 35 years. This much larger area of drawdown compared to Alternatives 2 and 3, and longer timeframe compared to Alternative 2 will result in the greatest impact on the wetlands of all the alternatives.

Table 5-8

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN
GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE
ALTERNATIVE 4

Item	Amount*
1. Construction Cost	
a. Groundwater Pretreatment System	
i. Oil/Water Separator	$25,000
ii. Equalization/Precipitation/Sludge Handling	200,000
iii. Product Collection Tank	3,000
iv. Neutralization	60,000
v. Filtration	180,000
vi. Air Stripper	173,000
vii. Preheater/Blower	28,000
viii. Polishing GAC Unit	210,000
Purchased Equipment & Installation (PE&I)	879,000
Instrumentation (10% PE&I)	88,000
Piping (21% PE&I)	185,000
Electrical (13% PE&I)	114,000
Building (26% PE&I)	229,000
Groundwater Treatment Plant Total (245 gpm)	1,495,000
b. Groundwater Collection System (see Table 5-9)	1,088,000
Groundwater Treatment/Collection Subtotal	2,583,000
Engineering (Design, Construction Management) (20%)	517,000
Contingency (25%)	646,000
Total	$3,746,000

* Costs are rounded to the nearest thousand.

* The O&M cost for 90 gpm treatment facility is estimated to be 80% of the 245 gpm facility or $337,000.

Table 5-8

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTHREADING, MASSACHUSETTS
REMEDIAL ACTION PLAN
GROUNDWATER TREATMENT/COLLECTION COMPONENT COST ESTIMATE
ALTERNATIVE 4

Item		Amount*
2.	**Future Equipment**	
	Replacement of Treatment Plant @ Year 20 (Q=180 gpm)	1,754,000
3.	**Annual Operations and Maintenance**	
	a. Utilities (45 HP, 0.1/kw•hr)	$ 35,000
	b. Labor (3 hr/d, $40/hr)	44,000
	c. Maintenance	127,000
	d. Chemicals (225 ton, $55/ton)	12,000
	e. Vapor Phase Carbon (65 lb/d, $4.25/lb)	101,000
	f. Liquid Phase Carbon (20 lb/d, $3.50/lb)	26,000
	g. Analytical ($2500/mo)	30,000
	h. Sludge Disposal (285 drums, $150/drum)	43,000
	i. Product Disposal (500 gal., $5/gal)	3,000
	Total	$ 421,000**
4.	**Annual Groundwater Monitoring**	20,000/YR
5.	**Present Worth of Future Equipment [P/F (6%, 20 yr) = .3118]**	547,000
6.	**Present Worth of Annual O&M**	
	a. O&M for 245 gpm facility (0-20 yrs) [P/A (6%, 20 yrs) = 11.4699]	4,829,000
	b. O&M for 180 gpm facility (20-35 yrs) [P/A (6%, 35 yrs) - P/A (6%, 20 yrs) = 3.0283]	1,021,000
		5,850,000
7.	**Present Worth of GW Monitoring [P/A (6%, 35 yrs) = 14.4982]**	290,000
	Total Present Worth (1+5+6+7)	$10,433,000

* Costs are rounded to the nearest thousand.

* The O&M cost for 90 gpm treatment facility is estimated to be 80% of the 245 gpm facility or $337,000.

Table 5-9

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER COLLECTION/DISCHARGE SYSTEM CONSTRUCTION COST ESTIMATE -- ALTERNATIVE 4

Description	Unit	Unit Cost	Cost*
1. Collection (On-Property)			
A. Overburden Wells	7	$3,500	$25,000
B. Bedrock Wells	10	$9,000	$90,000
C. Utility Trenches	3,600 ft	$20.00/ft	$72,000
D. Piping (Secondary Containment)	3,600 ft	$17.50/ft	$63,000
E. Overburden Well Pumps	7	$9,250	$65,000
F. Bedrock Well Pumps	10	$7,000	$70,000
		Subtotal	***$385,000***
2. Collection (Wetlands)			
A. Overburden Wells	2	$9,500	$19,000
B. Bedrock Wells	6	$12,500	$75,000
C. Utility Trenches	4,800/ft	$10.75	$52,000
D. Piping (Secondary Containment)	4,450/ft	$36.75	$164,000
E. Overburden Well Pumps	2	$4,000	$8,000
F. Bedrock Well Pumps	6	$1,500	$9,000
G. Easement	4	$10,000	$40,000

* Costs are rounded to the nearest thousand.

Table 5-9

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
REMEDIAL ACTION PLAN

GROUNDWATER COLLECTION/DISCHARGE SYSTEM
CONSTRUCTION COST ESTIMATE -- ALTERNATIVE 4

Description	Unit	Unit Cost	Cost*
H. Pump Test	1	$275,000	$275,000
		Subtotal	***$642,000***
3. Discharge			
A. Utility Trenches (Part of Wetlands Collection)	-		-
B. Piping	3,050 ft	$20/ft	$61,000
C. Easement (Part of Wetlands Collection)	-	$10,000	-
		Subtotal	***$61,000***
		Total	***$1,088,000***

* Costs are rounded to the nearest thousand.

In summary, Alternative 4 is the costliest alternative to implement from both the financial viewpoint and the impact on the wetlands.

5.3.4.5 *Risk*

The activities associated with Alternative 4 that could pose short term risks to facility workers and off site receptors are similar to those described for Alternatives 2 and 3. The on-property soil, sediment and groundwater activities and potential risks are the same for Alternative 4 as for Alternative 2 and 3. The major difference between Alternative 2 and 4 is that the groundwater recovery system in Alternative 4 includes a set of groundwater wells installed in the middle of the wetlands and another set at the eastern end of the wetlands. The trenches required (and the associated damage) for Alternative 4 will be more extensive than those required for Alternative 3.

The potential risks related to the operation of the vapor extraction systems are described in Alternative 2. The groundwater treatment system in Alternative 4 is expected to operate for a slightly longer period than Alternative 2, 35 years. Therefore, while the air emissions from this treatment system are controlled, they would occur over a slightly longer period as compared to Alternative 2, although shorter than Alternative 3. Similarly, the transport of sludge from the groundwater treatment system would occur over a longer period as compared to Alternative 2 and shorter period as compared to Alternative 3.

The risks to the wetland associated with the drawdown of the water level are greater for Alternative 4, as compared to Alternative 2 or 3. Modeling indicates that an estimated 830,000 square feet of wetlands would experience a drawdown of at least 0.5 feet over the 35 year period of operation. This drawdown can be expected to alter the wetlands vegetation and habitat within this area. Given the size of the area, any wetlands recovery would probably be a lengthy process.

According to the modeling results, Alternative 4 takes the shortest time to achieve remedial objectives (35 years) as compared to the other alternatives. Potential risks (during this time period) associated with groundwater beneath the wetlands or groundwater leaving the wetlands (with respect to impact on drinking water supplies, indoor air quality, or surface water quality as it affects aquatic life or potential water supplies) are considered insignificant for the same reasons described in Alternative 2.

The implementation of Alternative 4 is intended to achieve a level of No Significant Risk. The achievement of the applicable cleanup standards and objectives identified in Section 2.2 will ensure that any residuals at the site do not pose significant risks to health, safety, public welfare or the environment.

In summary, the implementation of Alternative 4 will achieve a level of No Significant Risk. During implementation, short term risks of the greatest concern (soil excavation and separate phase product removal) are the same as those identified for Alternative 2. In addition, this alternative poses short term risks to the wetland during construction of the wells and piping, and long-term risks due to potential construction of a road and during operation as a result of the drawdown. Risks posed by oil and hazardous materials at or from the site during the time required for remediation are not significant because use of the aquifer for drinking water purposes is not anticipated. In addition, other potential risks (to indoor air, surface water quality, and existing supply wells) are considered insignificant. Alternative 4 also poses greater risk to the wetlands associated with drawdown of the water table, because it affects a much larger area (compared to Alternatives 2 and 3) and for a longer timeframe than Alternative 2.

5.3.4.6 Benefits

Alternative 4 would ensure the restoration of the site's groundwater aquifer and allow for the productive reuse of the site. Any value of the site which may have been lost because of the contamination would be avoided upon completion of site remediation under Alternative 4.

In summary, Alternative 4 is identical to Alternatives 2 and 3 with regard to the benefits resulting from its implementation.

5.3.4.7 Timeliness

The implementation of Alternative 4 will eliminate uncontrolled sources of oil and hazardous material within 12 months. All soil remediation would be completed within 8 years. It is projected that cleanup objectives for groundwater on-property will be achieved in approximately 20 years, and for the wetlands in approximately 35 years (compared to 80 years for Alternative 2 and 65 years for Alternative 3).

5.3.4.8 *Non-Pecuniary Issues*

A groundwater treatment system would be on site for approximately 35 years under this alternative, but it will be constructed in a little used area of the site, near the existing basketball courts in the northeast section of the paved area. The vapor extraction systems at Tank K and Tank Farm would operate for only 3 and 8 years, respectively, and would be relatively unobtrusive. Their appearance would blend in with the industrial facilities currently existing at the on-property area.

Aesthetics of the wetlands would be affected by the construction of approximately 4,000 feet of trenching for transmission and discharge piping. In addition, changes to the wetlands vegetation will occur in the approximately 830,000 sf area affected by drawdown caused by operation of the groundwater extraction wells (approximately 25% of the total wetland area). The 35 year timeframe for this drawdown would make the recovery of wetlands vegetation more difficult after the wells are turned off.

In summary, implementation of Alternative 4 has a greater effect on aesthetic values than either Alternative 2 or 3 as a result of an increased area of impact in the wetlands.

5.4 PRESENT WORTH COST SUMMARY

To assist in concluding the evaluation of the alternatives, a summary has been prepared in tabular form showing the capital, operations and maintenance, and equipment replacement costs for each Alternative. This summary is shown in present worth format on Table 5-10.

Table 5-10

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTHREADING, MASSACHUSETTS
REMEDIAL ACTION PLAN
REMEDIAL ACTION ALTERNATIVE COST ESTIMATE SUMMARY

Alternative	Construction Cost ($)	Future Equipment	Present Worth of Future Equipment	O&M Cost ($/YR)	Present Worth of O&M	Groundwater Monitoring Cost ($/YR)	Present Worth of Groundwater Monitoring	Total Present Worth
1. No Action	-	-	-	-	-	20,000	330,000	330,000
2. On-Property Wells with Selected Soil Component	4,296,000	-	-	426,000	3,698,000	20,000	330,000	8,324,000
3. On-Property Wells and Wells at Eastern End of Wetlands with Selected Soil Component	5,912,000	2,924,000	598,000	550,000	6,480,000	20,000	326,000	13,316,000
4. On-Property Wells and Wells at Middle and Eastern End of Wetlands with Selected Soil Component	6,249,000	1,754,000	547,000	595,000	6,658,000	20,000	290,000	13,744,000

6.0 COMPARISON OF REMEDIAL ACTION ALTERNATIVES

Section 5.0 presented the detailed evaluation of the four remedial action alternatives in accordance with the eight criteria required by the revised (1993) MCP (310 CMR 40.0858). The relative ranking assigned by Wehran to each of these criteria are further summarized in Table 6-1. As indicated by this table, Remedial Action Alternative 1 (No Action) is unacceptable because it ranks poorly for the following criteria (effectiveness, reliability, risks, benefits, and timeliness). Most importantly, the No Action Alternative is unacceptable because it does not meet the cleanup objectives and therefore will not achieve a level of No Significant Risk on either a permanent or temporary basis. As a result, the No Action Alternative (Alternative 1) is eliminated from further consideration.

As indicated on Table 6-1, Alternative 3 ranks lower than Alternative 4 because of the greater time to achieve the cleanup objectives. Given that Alternative 3 is similar in its nature and objectives to Alternative 4, ranked slightly lower than Alternative 4, and does not achieve any additional benefits over Alternative 4, Alternative 3 is eliminated from further consideration.

In comparing the rankings on Table 6-1 between the two remaining alternatives, Alternative 2 received all good rankings with only one fair, whereas Alternative 4 received three fair and one poor ranking. In order to provide an additional basis for selection, both alternatives were evaluated with respect to feasibility (in accordance with 310 CMR 40.859(2) and 40.0860). The feasibility of a permanent solution refers to the technological feasibility, the costs and risks of the alternative as compared to the benefits, the availability of necessary expertise for the alternative, and the availability of off-site facilities, if necessary, other than land disposal facilities. In addition, the selected permanent solution must, to the extent feasible, reduce the concentrations of oil or hazardous material in the environment to levels that achieve or approach background. Both Alternatives 2 and 4 will achieve permanent solutions, approach background levels, and both are technologically feasible as described in Section 5.0. There are, however, distinct differences between these two alternatives in terms of a benefit-cost analysis as defined in 310 CMR 40.0860(6). This analysis evaluates whether the benefits of implementing a remedial action alternative justify the related costs (i.e., whether the incremental cost of conducting the remedial action alternative is substantial and disproportionate to the

Table 6-1

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
PHASE III FEASIBILITY STUDY
EVALUATION OF REMEDIAL ACTION ALTERNATIVES

Evaluation Criteria	Remedial Action Alternatives			
	1 No Action	2 On-Property Wells With Selected Soil Component	3 On-Property Wells and Wells at Eastern End of Wetlands With Selected Soil Component	4 On-Property Wells and Wells at Middle and Eastern End of Wetlands With Selected Soil Component
1. Effectiveness	P	G	G	G
2. Reliability	P	G	G	G
3. Implementability	G	G	F	F
4. Cost	G	G	P	P
5. Risk	P	G	F	F
6. Benefit	P	G	G	G
7. Timeliness	P	F	F	G
8. Non-Pecuniary	F	G	F	F

Note: G - Good, F - Fair, P - Poor

incremental benefit of risk reduction, environmental restoration, and monetary and non-pecuniary values). The following discussion compares the benefits and costs of Alternatives 2 and 4, and evaluates whether there are significant differences, as summarized in Table 6-2.

In conducting the benefit-cost analysis, it should be recognized that both Alternatives 2 and 4 will achieve soil/sediment cleanup objectives in the same time frame and that both alternatives will achieve the groundwater cleanup objectives on-property in an estimated 20 years. The effective distinction between these alternatives is that the cleanup objectives for groundwater beneath the wetlands would be achieved in approximately 80 years for Alternative 2 as opposed to 35 years for Alternative 4. (It should be noted that all cleanup times presented in this feasibility study are estimates, and that actual times may be shorter due to chemical and biological degradation). As described in Section 2.0, however, there is no reasonably likely foreseeable use of groundwater beneath the wetlands as an additional public water supply because it is a deficit basin (highly stressed aquifer) which cannot support additional withdrawal of groundwater without causing significant damage to the aquatic environment. Therefore, there is no significant difference between Alternatives 2 and 4 with respect to risk reduction for future water supply development of groundwater beneath the wetlands.

Another distinction between the two alternatives is that groundwater exiting the aquifer beneath the wetlands (and subsequently flowing beneath Concord Street and discharging to the Ipswich River) is estimated to meet cleanup objectives in 80 years in Alternative 2 as opposed to 15 years under Alternative 4. (As discussed in Section 5.0, both Alternatives meet GW-2 standards in the wetlands, and therefore potential risk of vapors into buildings located off-property is not an issue under either Alternative.) The following discussion addresses potential receptors of this groundwater and shows that this shorter time frame does not result in a significant difference in risk reduction between Alternatives 2 and 4.

One potential risk that was evaluated could result from groundwater discharging to surface water in the Ipswich River. Given that this portion of the River is a Class B surface water according to Massachusetts Surface Water Quality Standards 314 CMR 5.06, there is no potential for this portion of the River to be used as a public water supply without appropriate treatment. As a result, Alternative 2 would adequately address this issue, and

Table 6-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS
PHASE III FEASIBILITY STUDY
BENEFIT-COST ANALYSIS

(Differences Between Alternatives 2 and 4)

Alternative 2	Alternative 4	Significant Difference
BENEFITS		
• Groundwater beneath wetlands achieves cleanup objectives in 80 years.	• Groundwater beneath wetlands achieves cleanup objectives in 35 years.	• No significant difference in risk reduction. Highly stressed aquifer - no future water supply development.
• Groundwater leaving wetlands achieves cleanup objectives in 80 years.	• Groundwater leaving wetlands achieves cleanup objectives in 15 years.	• No significant difference in risk reduction: ▸ no GW-2 standards exceeded in wetlands ▸ aquatic life in Ipswich River - No GW-3 standards exceeded in wetlands ▸ drinking water from Ipswich River - Class B surface water requires appropriate treatment ▸ new water supply wells south of Ipswich River - highly stressed aquifer, therefore no future water supply development ▸ existing Town of Reading 82-20 and Town Forest wells - existing groundwater treatment system

Table 6-2

MARTIN MARIETTA CORPORATION
WILMINGTON/NORTH READING, MASSACHUSETTS

PHASE III FEASIBILITY STUDY

BENEFIT-COST ANALYSIS

(Differences Between Alternatives 2 and 4)

Alternative 2	Alternative 4	Significant Difference
COSTS/IMPACTS		
• Drawdown greater than 0.5 feet over an area of approximately 15,000 ft^2 for 20 years. Requires State and Federal Wetlands Permit.	• Drawdown greater than 0.5 feet over an area of approximately 830,000 ft^2 for 35 years. Requires State and Federal Wetlands Permit. Federal permit may not be approved because another feasible solution with less wetland impact (Alternative 2) exists.	• Significant differences in extent and length of time for long term deleterious impacts to wetlands. May be unable to obtain Federal Permit for Alternative 4.
• 1,000 feet of piping in wetlands.	• Eight recovery wells and 4,000 feet piping in wetlands.	• Significant differences in extent of short term impacts to wetlands.
• No service road required.	• Requires installation of service road for maintenance activities.	• Significant difference in long term impact to wetlands.
• Requires access agreements for piping.	• Requires access agreements for recovery wells and piping.	• Significant differences in number of agreements and need for continued O&M for Alternative 4.
• $8.3 million	• $13.7 million	• Additional $5.4 million for Alternative 4.

therefore there is no significant difference in risk reduction between the two alternatives. A review of analytical results for monitoring wells in the wetlands also indicates that no VOCs have been detected which exceed GW-3 standards, and therefore the protection of aquatic organisms in the Ipswich River is not an issue under either alternative.

Another concern with regard to risk reduction is whether contaminants in groundwater leaving the wetlands could potentially impact water supply wells; either new wells which might be located to the south of the Ipswich River, or the existing Town of Reading 82-20 and Town Forest Wells. As described in Section 2.0, because the Ipswich River Basin has been identified as a deficit basin (high stressed aquifer), there is no reasonably likely foreseeable use of the groundwater in this area as an additional public water supply. With respect to existing wells, in the event that groundwater leaving the site were to be drawn upgradient (and beneath the Ipswich River) into the Town of Reading 82-20 and Town Forest wells, potential contaminants would be addressed by additional water supply treatment which was funded by General Electric Aerospace in 1991. Therefore, there is no significant difference in the level of risk reduction between Alternatives 2 and 4 with respect to current and foreseeable uses of groundwater for public drinking supplies.

The one apparent benefit of Alternative 4 is that it would offer more rapid environmental restoration of the aquifer as compared to Alternative 2. In Wehran's opinion, however, this benefit is minimal given that there are no significant differences in risk reduction between the two alternatives.

The incremental costs of Alternative 4 compared to Alternative 2 are substantial, and include short term and long term deleterious impacts to the wetlands. The most significant impact is that pumping groundwater from multiple locations beneath the wetlands will cause drawdown of the water table during the entire estimated 35 years of pumping. As shown on Figure 4-13, drawdown of 1/2 foot or greater is anticipated over an area of approximately 830,000 square feet (19 acres). This degree of drawdown over such an extended period of time would likely alter the types of vegetation in the wetland, and possibly shift those affected portions of the wetlands to an uplands habitat. (The actual impacts are directly related to the existing vegetation community in the wetland, the depth of the rooting zones of the members of that community, and the drought and inundation tolerance of the members of the community.) In contrast, under Alternative 2, drawdown of greater than 1/2 foot is anticipated over a much smaller area of approximately 15,000 square feet, for a period of 20 years.

Under the Massachusetts Wetlands Protection Act (the Act) and regulations implementing the Act (310 CMR 10.55(4)(b)), actions which impact more than 5,000 square feet of wetlands can not be permitted without obtaining a Variance from the Commissioner of the DEP. Therefore, both Alternatives 2 and 4 would require such a variance. (It should be noted that under proposed revisions to Wetlands Protection Act Regulations 310 CMR 10.00, such a variance would not be required but remedial action alternatives would be analyzed with respect to demonstrating that the selected alternative would be least damaging to wetland resource areas.) A significant difference between the two alternatives may result from Federal Wetlands Regulations which require that a Federal Wetland permit (Section 404 of the Clean Water Act) be obtained for either alternative. One consideration of the Army Corps of Engineers in their review of this permit will be that no other feasible alternative exists. Given that Alternative 2 is a feasible alternative which achieves the objectives with much less deleterious effect, it is the most likely alternative to obtain a Federal Wetland Permit.

Alternative 4 would also cause significantly greater short term impacts to the wetlands than Alternative 2 because of the need to install eight recovery wells, and approximately 4,000 linear feet of piping across the wetland to transport groundwater to the on-property treatment plant, and treated groundwater for discharge into the wetlands. Installation of these structures would be primarily a temporary impact during construction. These structures would, however, also require some annual monitoring/maintenance (e.g., conditioning of recovery wells to remove iron or bacterial encrustations) during the anticipated 35 years of operation and therefore would likely require that a permanent road or pathway be built across the wetlands. In contrast, Alternative 2 would only require the construction of approximately 1,000 linear feet of pipe in the wetlands adjacent to the property (to transport treated groundwater for discharge to the wetlands) and no wells installed in the wetlands.

An additional issue posed by Alternative 4 is the need for a greater number of access agreements than Alternative 2. Under Alternative 4 these agreements will need to allow access for the installation of recovery wells and pipelines, with continued operation and maintenance of the recovery wells for decades. Obtaining these access agreements may cause significant additional costs and time delays. If such access agreements cannot be obtained, Alternative 4 would not be feasible.

Alternative 2 will cost approximately $5.4 million less than Alternative 4 ($8.3 million versus $13.7 million), and will achieve essentially the same risk reduction for groundwater beneath the wetlands area given that there is no reasonably likely foreseeable use of the groundwater in this area as an additional public water supply because it is a highly stressed aquifer. There is also no significant difference in the level of risk reduction between Alternatives 2 and 4 in terms of protecting potential water supplies in or adjacent to the Ipswich River based on: 1) the classification of the Ipswich River as Surface Water B, 2) the fact that this area is part of a highly stressed aquifer, and 3) nearby existing water supply wells already have treatment systems which could address any contaminants leaving the site. The incremental benefit of Alternative 4 (in terms of environmental restoration) of meeting cleanup objectives in 35 years as opposed to 80 years does not appear justified by the incremental cost and significant deleterious impacts to the wetlands.

Based on all of the above considerations, Alternative 2 is selected as the best feasible alternative because it achieves a similar level of risk reduction, and the incremental cost of Alternative 4 is substantial and disproportionate to the questionable incremental benefit of more rapid environmental restoration of the aquifer.

7.0 RECOMMENDED REMEDIAL ACTION ALTERNATIVE

7.1 DESCRIPTION OF SELECTED ALTERNATIVE

As described in Section 6.0, the recommended remedial action alternative is Alternative 2. This alternative consists of: 1) excavation of soils in the Eastern Parking Lot and the Drum Storage Area and sediment from Outfall 001, with off-site thermal desorption treatment of excavated soils and sediment; 2) soil vapor extraction in the Tank K and in the Tank Farm Areas; 3) collection of groundwater from on-property overburden and bedrock wells, and 4) treatment of groundwater on-site using an air stripper with granular activated carbon. Completion of this remedial action alternative will result in a Class A-2 Response Action Outcome in accordance with 310 CMR 40.1036(2) because a Permanent Solution will have been achieved, and because Activity and Use Limitations will not be required to maintain a level of No Significant Risk. Alternative 2 is described below in greater detail.

Soil Excavation and Treatment

The total volume of contaminated soil/sediment requiring excavation was estimated to be approximately 8,000 cubic yards (approximately 11,000 tons). Prior to the remedial design, additional soil sampling will be conducted to more accurately define the extent of contamination. The areas which would be excavated are the Eastern Parking Lot, Drum Storage Area and Outfall 001. For the most part, the excavation would be conducted utilizing sheet piling. Sheet piling will serve three purposes:

1. allow the excavation to be carried out in stages, minimizing disruption to the site;
2. aid in the recovery of separate phase product by minimizing collection of uncontaminated water; and
3. prevent recontamination of remediated areas.

Prior to the initiation of any field activities, a sampling program will be developed that defines the number of samples to be collected and analytical parameters to be analyzed as the soil is excavated. Strict adherence to this sampling program would be necessary in order to separate those soils which could be replaced in the excavation (i.e., no cleanup objectives exceeded) versus those soils which would require treatment. The excavated material would initially be screened both visually, and by instrumentation (e.g., a photoionization detector). Visual screening would be done throughout the excavation process, while the photoionization detector would be used to screen a minimum of every 10 cubic yards of excavated materials. Soils with recorded measurements greater than 10 ppm of the photoionization detector would be temporarily stockpiled at an area designated as requiring treatment. Conversely, excavated soils with recorded measurements less than 10 ppm on the photoionization detector, and no visual evidence of contamination, would be temporarily stockpiled at an area designated as potentially clean soil.

Once the soils are stockpiled, one sample per every 250 cubic yards of material would be collected and submitted to a laboratory for chemical characterization. The samples, designated as requiring treatment, would be analyzed for total petroleum hydrocarbons, volatile organics, semi-volatile organics, polychlorinated biphenyls, ignitability, corrosivity, reactivity, TCLP, metals, herbicides and pesticides, as required by the off-site thermal desorption facility. If the analytical results indicate that no soil cleanup objectives are exceeded and the soil is not considered a hazardous waste by characteristic, the soil would be used as backfill. If the analytical results verify the need for treatment, the soils would be loaded onto trucks and transported to an off-site thermal desorption facility. The soil designated as potentially clean soil would be analyzed for total petroleum hydrocarbons and VOCs to determine if cleanup objectives are exceeded. If the analytical results verify that no soil cleanup objectives are exceeded, the soil would be used as backfill. If the analytical results indicate the need for treatment, the soils would be analyzed for the additional parameters required by the off-site treatment facility. These soils would also be loaded onto trucks and transported to an off-site thermal desorption facility.

Due to the uncertainty of the levels of chlorinated compounds in the Eastern Parking Lot and Drum Storage Area soil, the selection of thermal desorption assures all excavated soils and sediment can be addressed. Off-site thermal desorption was selected for the following reasons: 1) remediation activities are less complex and more reliable at an established facility; and 2) less disruption will occur to existing operations. However, as was noted in Section 4.4.2, the ex-situ treatment of excavated soils could potentially be handled by thermal desorption (on- or off-site) or asphalt batching (on- or off-site). A final selection would be based on additional soil sampling performed prior to remedial design.

During the excavation of the Eastern Parking Lot, separate phase Stoddard solvent would be recovered. Although the details of such recovery will be developed in the remedial design, a brief description is provided below. Areas (approximately 50' x 50') would be blocked off by sheet piles. Excavated soil would be handled according to the sampling protocol indicated above to minimize the quantity of soil requiring transportation and treatment. Soil would be excavated approximately a foot below the groundwater table, and skimmers would be placed in the excavation to recover product which was not removed with the excavated soil. The recovered product/water mixture would be pumped through an oil/water separator and then through activated carbon. Effluent from the activated carbon would be sampled periodically to verify that it meets NPDES discharge limits. The treated groundwater would be discharged to the wetlands and the recovered product drummed and shipped off-site for treatment (incineration). Once the product is removed, the excavation would be filled with a combination of excavated material which did not require treatment and clean fill transported from off-site. The sheet piling would be left in place until the portion of the Eastern Parking Lot requiring remediation had been excavated to prevent recontamination of areas which were remediated.

Soil Vapor Extraction

The selected soil component of the remedial action alternatives includes soil vapor extraction systems in the Tank Farm and the Tank K Areas. The conceptual design of the soil vapor extraction systems is described below:

Extraction Wells - Extraction wells are similar in construction to monitoring wells. The proposed systems would use 4-inch PVC casing and screening. A highly permeable sand or gravel packing would be placed around the screen for optimal gas flow to the well. Above the pack, bentonite would be used to seal the hole. Multiple wells are proposed for both areas (3 wells in the Tank Farm and 5 wells at Tank K), and would be placed so that the flow zone intercepts the contaminated zone. The screened interval would extend from just above the existing water table to the water table depression caused by the groundwater collection system.

Blower - The driving force for the creation of a vacuum in the soil would be a positive displacement blower, a centrifugal blower or vacuum pump. A vacuum of 2 inches to 4 inches Hg for gravelly and sandy soils would be required to account for pressure losses in the collection system. The total flowrate for two systems would be 500 scfm (Tank K) and 750 scfm (Tank Farm). The influent header from the wells to the blower would be equipped with a vacuum indicator and manual flow control valve. The effluent pipeline would be equipped with a pressure indicator, temperature indicator and automatic discharge valve.

Piping - Manifold piping would connect the extraction wells and the blower/emission control system. The piping would be constructed of PVC, installed below ground and insulated, as necessary, to prevent freezing of condensed water. Piping would be sloped back toward the well. The manifold system would contain flow and pressure meters (to allow measurement during system operation) and flow control valves. Valves would be used to control which wells would be active at any one time.

Vapor Pretreatment - Vapors exiting the extraction wells may contain moisture and fine silt particles that may impair mechanical devices and vapor treatment operations. Air/water separators (knock-out drums) would be used to reduce moisture. Knock-out drums decrease the velocity of the incoming vapor stream, and allow gravity to separate dirt and the heavier liquid molecules from the lighter vapor stream. The removed water would be pumped to the groundwater treatment plant. In order to ensure acceptable adsorption if carbon is used for vapor treatment (i.e., in the Tank Farm Area), a heat exchanger would be provided to cool the extracted vapors due to the temperature increase caused by the blower.

Emission Control - The emissions control system would be the mechanism by which contaminants in the vapor stream would be treated prior to discharge to the atmosphere. For the Tank Farm Area, which has a relatively low estimated vapor concentration, the vapor stream would be passed through a bed of activated carbon. For the Tank K Area, a catalytic oxidizer would be used. Catalytic oxidation units operate by passing the heated vapor stream over a catalyst bed which facilitates combustion.

Groundwater Collection

Under this alternative, groundwater would be extracted through a series of wells placed in the vicinity of potential source areas at Tank K, the Eastern Parking Lot, Tank F, and Tank Farm. Three wells at Tank K would extract water from the overburden, while in the Eastern Parking Lot area, groundwater would be extracted from both the deep overburden and bedrock (three overburden/bedrock couplets would be placed along the eastern side of the Eastern Parking Lot). Four bedrock wells would be interspersed throughout the remaining area of the Eastern Parking Lot and the Tank Farm, with an additional bedrock well in the Tank F location and an overburden/bedrock couplet near the southern property boundary. In summary, groundwater would be collected through a total of three overburden wells at Tank K, and four overburden and nine bedrock wells in the Eastern Parking Lot and Tank Farm Area. The existing TF-1 bedrock well at the Tank Farm is included in the above total and would continue to be used.

These wells, once installed, would yield an estimated flow of approximately 65 gallons per minute. This flow would be pumped from the various wells and transmitted to a proposed groundwater treatment facility to be located in the vicinity of the existing basketball courts in the northeastern corner of the paved parking area by means of double-walled buried piping. Treated water would be discharged to surface wetland waters.

Groundwater Treatment

The proposed groundwater treatment system would consist of the following unit processes:

Oil/Water Separator - The purpose of the oil/water separator would be to remove separate phase product, such as gasoline or Stoddard solvent, which will float on top of the water and can be skimmed off, thus reducing the contaminant loading on the following process units in the treatment train. Separate phase product that is skimmed off would then be transferred to a product storage tank and allowed to accumulate prior to final disposal off-site.

Equalization Tank - The equalization tank would serve to dampen out wide swings in flow by allowing water to accumulate in it during varying inflow conditions, while the water is pumped out of it at a constant rate. Thus, the downstream unit processes would experience a uniform flow rate even if the actual flow rate of water entering the treatment system were to fluctuate with time. The equalization tank would receive inflow from the wells, and also from process units including used filter backwash water, supernatant from the sludge thickener, and filtrate from the filter press.

Precipitation Tank - Water leaving the equalization tank would be pumped into the precipitation tank. Here, certain chemicals (such as lime, sodium hydroxide, etc.) and flocculants would be added and mixed into the water using a propeller like device. The purpose of adding these chemicals would be to cause minerals such as iron, or carbonates of magnesium or calcium, which are naturally dissolved in the water, to precipitate as a solid form so they can be flocculated and settled out of the flow stream, thus removing them before they can cause problems in downstream process units, such as scaling and plugging of packing in stripping towers, or plugging of carbon filters.

Flocculation Tank - The flocculation tank is a large unit where flow velocities are reduced and the water gently agitated to promote contact between adjacent particles which have transitioned from the dissolved into the solids phase. This agitation and contact would cause the development of even larger particles (flocs) which, after agglomeration, can be settled out.

Settling Tank - In this tank the flocculated particles enter a quiescent zone where they would slowly fall to the bottom of the tank and collect as a sludge. The collected sludge, once removed, would be pumped to a sludge thickener for dewatering. Supernatant from the sludge thickener would be returned to the equalization tank.

Neutralization Tank - As part of the precipitation process, lime would be added to the water to raise the pH to about 9 or 10 and facilitate precipitation. In the neutralization tank, acid would be flash mixed into the settled water to reduce the pH to neutral.

Filter Beds - Filter beds would remove any solids which may have passed through the settling tank without having been removed. This would protect the subsequent process units from a solids problem. The filters consist of granular media which would be backwashed with clean water automatically once the surface of the filter became plugged. After backwashing was complete, the used backwash water would be returned to the equalization tank.

Packed Tower - From the filter beds, the water would be pumped to the top of the packed tower, where it would trickle downward through densely packed media. The media usually consist of plastic spheres less than 2" in diameter, which as the water passes over them, have the effect of greatly increasing the surface area of the water trickling through. As the water trickles down, air would be blown upward through the tower. As the air passes over the thin film of water on the media, the air would strip the volatile contaminants from the water and carry them away in the air stream. The water would then pass from the packed tower into the liquid phase granular activated carbon for further treatment, and the air would pass through a vapor phase granular activated carbon.

Sludge Thickener - Sludge pumped from the flocculation settling tank would enter the sludge thickener and remain there for 16 - 20 hours during which time it would densify, and water would separate out and float on top. The water would be drawn off and returned to the equalization tank. The sludge would then be pumped to the filter press.

Granular Activated Carbon - The liquid phase granular activated carbon would clean the water that has left the packed tower, and adsorb most remaining contaminants in a polishing step. The water would then be discharged to the surface of the wetlands via a discharge pipe approximately 1800 feet in length (1000 feet of which is installed in the wetlands). Vapor phase granular activated carbon would perform a similar task for air bearing contaminants exiting the air stripper.

7.2 PRELIMINARY SCHEDULE FOR IMPLEMENTATION

The following is a preliminary schedule for implementation of Phase IV activities, which assumes DEP approval of the Remedial Action Plan by December 15, 1993.

Perform Additional Soil Sampling/Pump Tests	August 1994
Submission of Remedy Implementation Plan (RIP) (Design, Plans & Specifications, O&M Plan, H&S Plan, Permits)	April 1995
DEP Approval of RIP	July 1995
Obtain Permits and Construction Bids	March 1996
Complete Construction	March 1997
Complete Start-Up Activities	June 1997
Submission of Final Inspection Report and Phase IV Completion Statement	August 1997

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