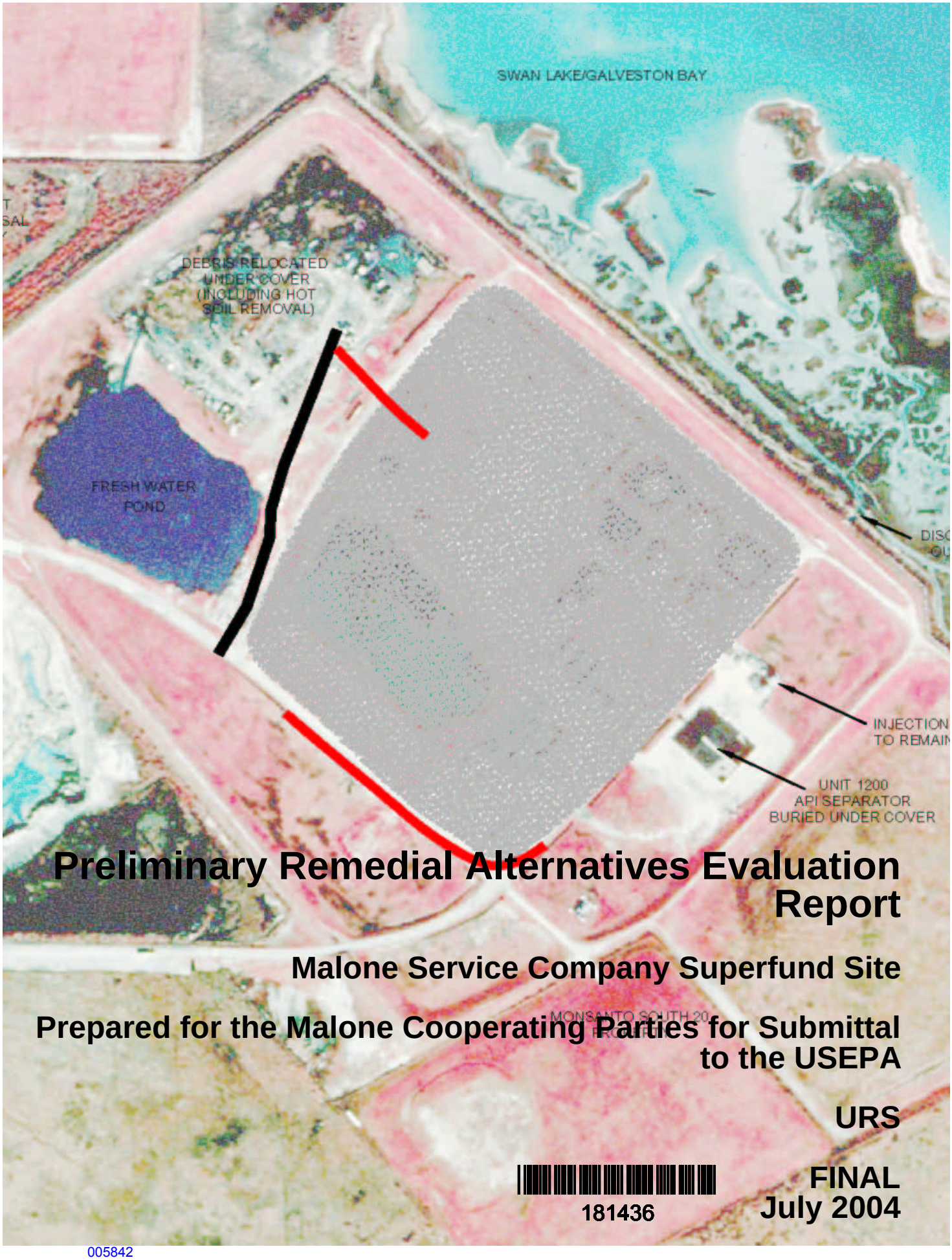

Preliminary Remedial Alternatives Evaluation Report

Malone Service Company Superfund Site

Prepared for the Malone Cooperating Parties for Submittal to the USEPA

URS

181436

FINAL
July 2004

EXECUTIVE SUMMARY

The Malone Service Company, Inc. (MSC) site is located in Texas City, Galveston County, Texas, in an industrial and petrochemical area constructed on the shores of Swan Lake and Galveston Bay. The MSC Superfund Site was proposed to the National Priorities List (NPL) on August 24, 2000, and was placed on the NPL on June 14, 2001. An Administrative Order on Consent (the "Order") for the remedial investigation/feasibility study (RI/FS) was issued by the United States Environmental Protection Agency (USEPA) on September 29, 2003 to the Malone Cooperating Parties (Respondents).

The respondents are required to provide USEPA with a Preliminary Remedial Alternatives Evaluation Report (PRAER). The objectives of this PRAER are to:

- develop remedial action objectives;
- develop a list of potential state and federal applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) advisories, criteria or guidance;
- develop and screen alternatives evaluated at similar waste sites;
- determine a presumptive remedy;
- identify candidate treatability studies; and
- develop conceptual treatability study plans.

The development of a presumptive remedy(ies) for affected media at the MSC Superfund Site in this document does not eliminate the evaluation of other remedial alternatives during the FS if data developed during the RI indicate that other technologies may be more suitable for the site contaminants. The presumptive remedy(ies) are selected using data and experience from the MSC Superfund Site and from other Superfund or related waste sites with similar settings, histories, and contaminants to eliminate remedial alternatives.

In order to provide sufficient background for the development of remedial alternatives, a brief history of the site and a discussion of operating units and chemical contamination is presented. This information is used to develop a site conceptual model and preliminary remedial action objectives. Monitored natural attenuation was chosen as the groundwater remedy for eight of the comparable sites and a groundwater pump and treat process was chosen as the remedy for four sites. Generally, monitored natural attenuation was chosen as the groundwater remedy in conjunction with an active soil/sludge remedy. The most frequently chosen remedies for the soil or sludge were bioremediation and solidification/stabilization.

Applicable information for contaminants, types of units, geology/hydrogeology, and general settings for Superfund sites in Region 6 were evaluated to determine which Region 6 Superfund Sites were comparable to the MSC Superfund Site. For the sixteen sites deemed comparable to the MSC Superfund Site, applicable information of considered, proposed, implemented or inappropriate

remedial alternatives or technologies were evaluated and discussed.

Three sites, deemed most representative of the conditions at the MSC Superfund Site, were chosen for a detailed comparison of the source areas, COCs, geology, and hydrogeology. The three sites, the Brio Refining Superfund Site, French Limited Superfund Site, and the MOTCO Superfund Site, have been extensively investigated and the source control remedial actions have been completed. The regional geology and hydrogeology and chemical characteristics of the sites are compared to the MSC Superfund Site. The remedial technologies considered for each site, as well as the advantages, disadvantages, and costs for each technology are presented in the discussion. The actual implementation of the remedies, including successes and failures are also discussed.

Based upon the data gathered during the initial screening and detailed evaluation of the comparable USEPA Region 6 Superfund Sites, the following presumptive remedies are recommended:

The recommended presumptive remedy for sludge, wastes and soils has several components:

1. Bioremediation of the sludge in the Sludge and Oil Pit, API separators and tanks to reduce volume and toxicity.
2. Injection of the treated related water into the underground injection well.
3. Solidification and stabilization of the residuals in the sludge pit.
4. Capping the solidified/stabilized residuals, possibly along with contaminated soils.
5. Maintenance of the existing hurricane levee and controlled stormwater drainage system.

The recommended presumptive remedy for groundwater has three components:

1. Installation of a slurry wall in the sand channels on either side of the Sludge Pit.
2. Maintenance of an inward gradient by pumping the groundwater inside the slurry wall and injection of the treated water into the underground injection well.
3. Monitored natural attenuation of groundwater outside the slurry wall.

The recommended presumptive remedy for sediments has two components:

1. No action for on-site sediments.
2. Natural siltation for off-site sediments in the marshy area east of the site between the flood protection levee and Swan Lake under the existing implemented TexTin OU-4 Remedial Action.

Candidate treatability studies and data gaps are discussed for each of the presumptive remedies. In addition, the last section summarizes the ARARs and TBCs for the site and recommended presumptive remedies.

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ACRONYM LIST

API	American Petroleum Institute
ARARs	Applicable or relevant and appropriate requirements
bgs	below ground surface
BSTF	Brio Refining Superfund Site Task Force
BTEX	Benzene, toluene, ethylbenzene, xylenes
CAG	Community Action Group
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm/sec	centimeter per second
COCs	Chemicals of Concern
COD	Chemical Oxygen Demand
DNAPL	Dense non-aqueous phase liquids
ECA	Environmental Consulting Associates
ERA	Ecological Risk Assessment
ESD	Explanation of Significant Differences
FEMA	Federal Emergency Management Agency
FLTG	French Limited Task Group
FS	Feasibility Study
ft^3	cubic feet
ft/yr	feet per year
GCWDA	Gulf Coast Waste Disposal Authority
gpd/ft	gallons per day/foot
HRS	Hazard Ranking Summary
LNAPL	Light non-aqueous phase liquids
MCL	Maximum Contaminant Level
MNA	Monitored Natural Attenuation
MSC	Malone Service Company
msl	mean sea level
NCP	National Contingency Plan

NOR	Notice of Registration
NPL	National Priorities List
OU	Operable Unit
PAHs	Polycyclic aromatic hydrocarbons
PCBs	Polychlorinated Biphenyls
PCSR	Preliminary Site Characterization Report
PPE	Probable Point-of-Entry
PR/VSI	Preliminary Available Data Review/Visual Site Inspection
PRAER	Preliminary Remedial Alternatives Evaluation Report
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
ROD	Record of Decision
SARA	Superfund Amendments and Reauthorization Act
SSI	Screening Site Inspection
START	Superfund Technical Assistance and Response Team
SVOCs	Semivolatile Organic Compounds
TCEQ	Texas Commission on Environmental Quality
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TDWR	Texas Department of Water Resources
TMDL	Total Maximum Daily Load
TNRCC	Texas Natural Resource Conservation Commission
TPH	Total Petroleum Hydrocarbons
TSCA	Toxic Substances Control Act
TWC	Texas Water Commission
TWDB	Texas Water Development Board
TWPCB	Texas Water Pollution Control Board
TWQB	Texas Water Quality Board
UIC	Underground Injection Control

URS	URS Corporation
USEPA	United States Environmental Protection Agency
VOCs	Volatile Organic Compounds
yd^3	cubic yards

1.0 INTRODUCTION

The Malone Service Company, Inc. (MSC) site is located in Texas City, Galveston County, Texas, in an industrial and petrochemical area constructed on the shores of Swan Lake and Galveston Bay. The MSC Superfund Site was proposed to the National Priorities List (NPL) on August 24, 2000, and was placed on the NPL on June 14, 2001. An Administrative Order on Consent (the "Order") for the remedial investigation/feasibility study (RI/FS) was issued by the United States Environmental Protection Agency (USEPA) on September 29, 2003 to the Malone Cooperating Parties (Respondents).

1.1 Statement of Work

Included with the Order is a Statement of Work that describes the requirements for the Scoping Phase of the RI/FS. The first deliverable, the Preliminary Site Characterization Report (PSCR), provided a summary of the known site information (URS 2004a). The respondents are also required to provide USEPA with a Preliminary Remedial Alternatives Evaluation Report (PRAER). The objectives of this PRAER are to:

- develop remedial action objectives;
- develop a list of potential state and federal applicable or relevant and appropriate requirements (ARARs) and to-be-considered (TBC) advisories, criteria or guidance;
- develop and screen alternatives evaluated at similar waste sites;
- determine a presumptive remedy;
- identify candidate treatability studies; and
- develop conceptual treatability study plans.

The development of a presumptive remedy(ies) for affected media at the MSC Superfund Site in this document does not eliminate the evaluation of other remedial alternatives during the FS if data developed during the RI indicate that other technologies may be more suitable for the site contaminants. The presumptive remedy(ies) are selected using data and experience from the MSC Superfund Site and from other Superfund or related waste sites with similar settings, histories, and contaminants to eliminate remedial alternatives.

1.2 Objectives

The FS phase of the RI/FS has typically been used to evaluate an extensive number of possible remedial alternatives by contaminant, media, and technologies appropriate for the site, during and after the RI. The RI is often implemented prior to the FS and focuses on determining the nature and extent of impacted media and evaluating the risk of the impacted media to human health and the environment. With this approach, the RI data often do not meet the needs for evaluating remedial alternatives and technologies that are most likely to be selected for the site.

To support the development of a more focused, flexible, and functional approach to the RI, the PRAER will use the data and experience from the MSC Superfund Site and from other sites with similar settings, histories, and contaminants to eliminate inappropriate remedial alternatives. The remedial alternatives from these other sites, considered and evaluated in this PRAER were:

- selected at other sites but failed and the site conditions are similar to those at MSC Superfund Site;
- considered but not selected and the site conditions (or rationale) are similar to those at the MSC Superfund Site; and
- not considered or selected and the rationale for not selecting the remedy applies to the MSC Superfund Site.

The PRAER focuses on those remedial alternatives that were:

- selected and successfully implemented at sites similar to the MSC Superfund Site; or
- were considered but were not selected and the reasons for eliminating the alternative are not applicable to the MSC Superfund Site.

The PRAER selects, at a minimum, remedial alternatives and technologies that comply with the National Contingency Plan (NCP) requirements that containment, treatment and no-action alternatives be developed and considered in the FS (USEPA 1988a). Data needs for the selected preliminary remedial alternatives are identified. In addition, the selection of the preliminary remedial alternatives allows conceptual development of treatability studies in this PRAER, incorporation of data needs into the RI workplan sampling strategy, preparation of detailed treatability study plans as part of the RI/FS Work Plan, and performance of the treatability studies during the RI.

1.3 Report Structure

This Report consists of the following Sections:

- Section 1, Introduction, provides a statement of the purpose and structure of the report;
- Section 2, Site Background, discusses the MSC Superfund Site location, history, and operating units as well as previous remedial responses;
- Section 3, Conceptual Site Model, discusses exposure pathways and remedial action alternatives for the MSC Superfund Site;
- Section 4, Initial Screening of Comparable Superfund Sites, summarizes the setting, contaminants, and remedial alternatives for sixteen UESPA Region 6 Superfund sites;
- Section 5, Detailed Evaluation of Comparable Sites, presents and summarizes the history, contaminants, site settings (hydrogeology and geology), remedies evaluated in the FS, and remedies implemented for three local Superfund sites most comparable to the MSC

Superfund Site;

- Section 6, Remedial Alternatives, discusses the technologies for remedial alternatives evaluated at the comparable sites;
- Section 7, Presumptive Remedy, presents the conceptual presumptive remedies for the MSC Superfund Site and recommends and outlines candidate treatability studies;
- Section 8, Preliminary ARARs, summarizes the preliminary applicable or relevant and appropriate requirements (ARARs); and
- Section 9, References, lists the data sources used to compile this report.

This report refers to several predecessor agencies of the Texas Commission on Environmental Quality (TCEQ). These agencies are the Texas Water Pollution Control Board (TWPCB), Texas Water Quality Board (TWQB), and Texas Department of Water Resources (TDWR), Texas Water Commission (TWC), and the Texas Natural Resource Conservation Commission (TNRCC). For consistency and clarity throughout this document, the predecessor agencies are referred to as the TCEQ.

2.0 SITE BACKGROUND

The PRAER's selection of preliminary remedial alternatives for the MSC Superfund Site is based on two components:

1. an understanding of the site location, history, operations, geology and hydrogeology, ecological setting, and contaminants at the MSC Superfund Site; and
2. an understanding of the site location, history, operations, geology and hydrogeology, ecological setting, and contaminants at the comparable Superfund sites.

This section of the report summarizes the site location, history, operations, geology and hydrogeology, ecological setting, and contaminants at the MSC Superfund Site, presented in detail in the PSCR (URS 2004a).

2.1 Site Location

The MSC Superfund Site is located on Campbell Bayou Road in Texas City, Galveston County, Texas, on the shores of Swan Lake and Galveston Bay, approximately 1.6 miles east-southeast of the intersection of Loop 197 and State Highway 3 (Figure 1). The MSC Superfund Site is bordered to the east and northeast by Galveston Bay and Swan Lake, which is an embayment of Galveston Bay. The Monsanto South 20 site borders the site on the southeast. Undeveloped land, owned by Scenic Galveston, in the form of marsh and wetlands, border the southern portions of the MSC Superfund Site. The Gulf Coast Waste Disposal Authority (GCWDA) Campbell Bayou facility is located on the western border of the facility. Northwest of the MSC Superfund Site is a closed Texas City landfill. The MSC Superfund Site encompasses approximately 150 acres (TNRCC 1998). The process area constituted approximately 75 acres (Kearney 1989).

2.2 Site History

The MSC Superfund Site received a variety of waste products from surrounding industries, including acids and caustics; contaminated residues and solvents; gasoline and crude oil tank bottoms; contaminated earth and water from chemical spill cleanups; general industrial plant wastes; phenolic tars; and waste oils (USEPA 2003a). The liquids injected into the two deep wells included wastewater submitted to the facility for disposal, stormwater from the Sludge Pit, Oil Pit, and separators, and decontamination water collected in the separators. The MSC Superfund Site also accepted approximately 40 tons of waste from the Department of Defense monthly. Approximately 800 tons of solidified wastes were sent off-site for disposal in a hazardous waste landfill (Kearney 1989).

The MSC Superfund Site began operating in 1964 as a reclamation plant for waste oils and chemicals (TWPCB 1964). The facility was permitted to dispose of liquid hazardous and non-hazardous waste by means of deep well injection under Injection Well Permit Nos. WDW-73 and WDW-138. Injection Permit No. WDW-73 was issued in 1970 and Injection Permit No. WDW-138 was issued in 1977 (TNRCC 1998). Currently, stormwater from some site units is managed by injection into WDW-138.

The MSC Superfund Site was permitted as a commercial storage, processing and disposal facility authorized to store and process industrial solid waste under TCEQ Hazardous Waste (HW) Permit No. HW-50003 issued on September 14, 1984 (TDWR 1984). The permit included the following storage/treatment units:

- Ninety-six aboveground storage tanks for wastewater or recovered oil
- four underground tanks to service a decanning unit (not built as of 1988)
- one hydrocarbon distillation unit
- one American Petroleum Institute (API) separator
- five hazardous wastewater filters

The permit authorized the receipt of Class 1 and Class 2 industrial solid waste with the exception of wastes containing polychlorinated biphenyls (PCBs), explosives and radioactive or nuclear waste material. The permit authorized the discharge of stormwater runoff. An additional API separator was listed on the company's Notice of Registration (NOR).

Physical operations ceased in January 1996 and the MSC Superfund Site has been inactive since then. On May 6, 1997, the TNRCC revoked permits HW-50003, WDW-73 and WDW-138 (TNRCC 1998). Waste materials, two American Petroleum (API) separators, two underground injection wells, roll-off bins, a freshwater pond, sludge impoundment, numerous tanks containing liquid and sludge, chemicals within the facility laboratory, and metal drums inside small buildings were left on the MSC Superfund Site after the plant was closed.

2.3 Site Description

During early operations, incoming wastes were placed into two earthen, unlined pits (Figure 2), which comprise the earthen impoundment formed by excavating into the sand of a paleochannel that crosses from southwest to southeast beneath the MSC Superfund Site. Wastes with high solids or high water content were placed in the larger pit ("Sludge Pit"). The oil fraction that rose to the top of the larger pit was skimmed off the surface and deposited into the smaller portion of the earthen impoundment ("Oil Pit"). This oil was then pumped to one of several tanks for treatment, after which it was resold as waste oil for energy recovery (USEPA 2003a). Subsequently, the MSC Superfund Site added one and then a second API separator to replace the pits.

Unless otherwise referenced, the unit descriptions below were compiled from the Preliminary Available Data Review/Visual Site Inspection (PR/VSI) report submitted to USEPA by A. T. Kearney and Camp, Dresser and McKee (Kearney 1989). Figure 2 shows the locations of the units on an aerial photograph of the site.

2.3.1 Earthen Impoundment ("Sludge Pit")

The MSC Superfund Site operated an unlined, earthen pit for the separation and equalization of incoming waste streams prior to construction of the concrete API separators. This impoundment originated as a sand excavation pit for the local construction industry (ECA 1989a). The earthen impoundment operated from 1964 to 1979. The impoundment is located near the center of the facility (Figure 2). This impoundment consists of two pits. For the purposes of this report, the large pit is termed the "Sludge Pit" and the small pit is termed the "Oil Pit".

Volume estimates for the Sludge Pit range from 4.4 million cubic feet to 8.3 million cubic feet (ft^3). Most of the volume variation is due to the differences in estimating the depth of the earthen impoundment. Earthen dikes surround the impoundment with a height of about 15 feet above natural grade and an average crest elevation of about 23 feet above mean sea level (msl). Horizontal dimensions and elevations of the earthen impoundment were profiled during the treatability studies conducted in 1989. Depth profiles of the waste material within the Sludge Pit were measured along transects within the impoundment with the deepest points approximately 40 feet. The average depth of the impoundment floor was calculated as approximately 37 feet below the crests of the levees (ECA 1989a).

The Sludge Pit was used as a waste receiving/treatment unit for the separation of oil, water, and solids from a variety of industrial waste streams. The solids and oils were separated from the aqueous waste, with the solids remaining in the impoundment. The oils were then recovered from the impoundment and the aqueous phase was disposed of by deep well injection (MSC 1994a).

The Sludge Pit was reportedly taken out of service in 1979. Malone Services Company began closure of the earthen impoundment as a unit not subject to the requirements of the Resource Conservation and Recovery Act (RCRA) in 1983. A synthetic cover/liner and sand were placed in one portion of the Sludge Pit and a leachate collection system was installed around the perimeter of the impoundment. Closure activities were suspended in 1986 when the TCEQ filed a civil action against the Malone Services Company for non-compliance with the agreement.

2.3.2 Earthen Impoundment ("Oil Pit")

The Oil Pit operated from 1964 to 1979. The dimensions are 20 feet by 100 feet by 33 feet deep with volume estimates ranging from 560,000 ft^3 to 800,000 ft^3. This unlined pit was used to store oils and organic wastes separated from the aqueous or solid fraction of the waste in the Sludge Pit. Oils from this pit were pumped to blending tanks for further treatment or to storage tanks for use as reclaimed fuel.

Closure of this pit began in 1983 and was suspended in 1988. The pit was reportedly covered with permeable and impermeable liners and capped with soil. However, the cap has undergone severe subsidence with excessive ponding of stormwater.

2.3.3 Other Pits

The Former Backwash Pit operated from 1970 to 1982. The Backwash Pit was located approximately 100 feet south of the Unit 700 area and directly east of the Oil Pit. Based on the description of the location in the PR/VSI, an approximate location of the Backwash Pit is shown in Figure 2. The pit volume was approximately 12,500 ft^3 (50 feet by 50 feet by 5 feet). The pit was used to dispose of the Unit 700 (WDW-73) filter backwash water. In 1982 (or later), Malone Services Company excavated the pit until the natural clay was visible. No confirmatory sampling was performed. Excavated soils were reportedly placed in the Sludge Pit and the Backwash Pit was backfilled and returned to the original surface grade.

A 1969 aerial photograph (Figure 3) of the MSC Superfund Site shows five oil/water pits (slop oil pits) near the Sludge Pit. The pits were not visible in a 1978 aerial photograph. The location of one pit appears to be under the paved area behind the shop and north of the earthen impoundment and two pits were located in the current Tank 300 area. The other two pits were located in a cleared area north of the Tank 300 area and east of the 400 series tanks. Documentation of closure activities for these pits has not been located.

2.3.4 Freshwater Pond

The drainage ditch system throughout the facility discharged into the Freshwater Pond located on the west side of the MSC Superfund Site (Figure 2). The drainage system collected stormwater and any spills that escaped the containment areas in the plant process areas. The Freshwater Pond is an excavated pit with a volume of approximately 20,000,000 gallons (267,000 ft^3) (MSC 1994a).

2.3.5 Unit 100 API separator

The Unit 100 API separator is an in-ground, concrete unit consisting of four separate basins (A, B, C, and D) and a system of baffles and/or weirs (Figure 2). A truck unloading area was adjacent to the separator. The separator is located near the center of the MSC Superfund Site, adjacent to and southeast of the Sludge Pit. The separator is located above the paleochannel that crosses beneath the MSC Superfund Site. The separator was installed in 1978. The following wastes were managed in the separator: rinse water/wastewater, lubricating oils, contaminated rainwater, paint solvents and spent solvent mixtures, waste oils, separator sludge, and separator solids.

The separator was used for the equalization of various waste streams and separation into aqueous, organic, and solid phases. The oil fraction was removed from the surface of the separator and pumped or trucked to the oil blending tanks for reclamation. The aqueous phase was ultimately pumped to one of the injection wells for disposal. Solids were removed with a backhoe to a solids handling area on the far side of Basin A or to the Solids Mixing Bin. Large equipment, including the backhoe bucket, was cleaned at the Unit 100 API separator. Reportedly, acid neutralization, caustic neutralization and flocculation also occurred in the separator.

The volume of the Unit 100 API separator was estimated as 625,000 ft^3 (TNRCC 1998). The dimensions of separator basins A and B are 135 feet by 20 feet by 6 feet deep and 100 feet by 30 feet by 6 feet deep for Basins C and D. The separator is surrounded by a 12-inch thick concrete wall and underlain by a 12-inch thick concrete floor. The liner system for the unit was reported to be in excellent condition during the 1981 Site Inspection (USEPA 1981), however, at least three subsequent state inspections documented a lack of integrity assessments (TNRCC 1998).

Pumps and filters were associated with Unit 100. Three pumps, one wastewater and two reclaimed oil pumps (with oil screen filters), were located in the Unit 100 Pump House. Two more pumps and two wastewater filters were located on a concrete pad outside the Unit 100 pump. The wastewater filters simultaneously filtered water prior to disposal in the injection wells. Each filter had an approximate capacity of 100 barrels. The gravity sand media was changed approximately every 18 months and fine sands and spent media were deposited in the Unit 100 API separator Basin.

2.3.6 Unit 1200 API separator

The facility operated one additional separator, designated as the Unit 1200 API separator. The separator is located on the east side of the plant processing area, just south of the Unit 1100 area (Figure 2). This separator served the same purpose as the Unit 100 API separator. Most of the waste that entered the plant was treated in the Unit 100 API separator; the Unit 1200 API separator served as a backup. This separator was installed and put in service in 1987.

The separator consists of:

- four large (60 feet by 60 feet by 6 feet deep) settling basins (approximately 86,400 ft^3),
- two small (20 feet by 60 feet by 6 feet deep) settling basins (approximately 14,400 ft^3), and
- one large (145 feet by 60 feet by 6 feet deep) solids treatment area (approximately 52,200 ft^3).

Each basin is lined with 12-inch thick concrete floors and outer walls, and 5-foot high inner walls. The separator is surrounded by a 20-inch high, 2-foot thick concrete wall. This wall is surrounded on all four sides by a concrete pad.

Wastes flowed between the four large and the two small basins by overflowing the internal concrete walls. Water and oils in the small basins were transported to the Unit 100 API separator using a vacuum truck. Sludge was removed from the basins using a clamshell bucket and placed in the solids treatment area (Kearney 1989). A sludge profile generated during the 1999 removal assessment showed the sludge depths to be approximately one to 6.8 feet (E&E 1999).

Sludge was mixed with fly ash and gypsum in the solids treatment area using a small front loader. The solidified solids from the Unit 100 API separator were also placed in the solids treatment area. After solidification, solids were loaded into dump trucks and reportedly hauled off-site for disposal.

2.3.7 Above-Ground Storage Tanks

Several aboveground storage tanks (ASTs) were constructed at the facility (Figure 2). These tanks, which are located in Unit 300, Unit 400, and Unit 800, accepted oils pumped or transported by vacuum truck from the Unit 100 or Unit 1200 separators. The 700 and 1100 series tanks were used to support the injection well disposal activities.

The Unit 300 Tank Farm contained 46 tanks. Tanks 301 – 336 (36 tanks) were used to store/blend reclaimed oil. Two tanks (Tanks 337 and 339) were used as final product storage for reclaimed oil. Tanks 338 and 340 were reportedly unused because of unstable soil conditions at the proposed tank locations. Six tanks (Tanks 341 – 346) stored materials used in the plant processes such as brine water and barite. All tanks are located within the same clay containment area.

The Unit 400 Tank Farm contained six tanks (Tanks 401 – 406) which were used to blend reclaimed oils. Eight additional tanks (Tanks 407 – 414) were permitted but never built. All six tanks are located within the same clay containment area. A transfer sump for the Unit 400 Tank Farm collected spilled material during transfers in and out of the tanks. The sump was constructed using 6-inch thick concrete. The sump capacity was approximately 100 gallons.

The Unit 800 tank farm consisted of six ASTs (Tanks 801 – 806). Each tank was contained within its own earthen containment. The tanks were used to store and blend reclaimed fuel oil. Three transfer sumps were located approximately 200 feet apart on the southern border of the Unit 800 Tank Farm. The capacity of each sump was approximately 100 gallons.

2.3.8 Sumps

Five “transfer” sumps were located around the inlet and outlet pump lines of several tanks. These sumps were reportedly used to collect any spills from pumping oil or wastewater in or out of these tanks. Three sumps were located in the Unit 800 Tank Farm, one at Tank 700, and one at the southern end of the Unit 400 Tank Farm. An unused sump (in 1988) was located at the north end of the Unit 400 Tank Farm. Two 2200-gallon concrete-lined sumps were located at the wastewater disposal areas (Units 700 and 1100). Materials collected in the sumps were reportedly pumped into a vacuum truck and taken back to the Unit 100 API separator.

2.3.9 Distillation Unit

The distillation unit (Unit 900) was constructed in 1978 to treat incoming oil wastes by distillation (Figure 2). The unit was reportedly only used once, in 1985, when crude oil was distilled into light (naphtha and kerosene) and heavy fractions. The unit consisted of two distillation columns, one boiler, and thirteen tanks (901 – 913). The unit is located on a concrete pad and is surrounded by a 3-foot high concrete wall.

2.3.10 Injection Well WDW-138

This injection well is located in the northeast corner of the plant process area and was part of the Unit 1100 waste disposal area (Figure 2). This well was the facility's primary injection well, disposing of most of the wastewater treated at the plant. Wastewater was injected for disposal into the Miocene sands at a subsurface interval between 3800 and 5300 feet.

Brine water for maintaining a positive pressure differential was stored in a small tank located within a concrete containment area near the well. Piping to the well was constructed above concrete pads, as was the wellhead. A concrete-lined 2200-gallon capacity sump was located directly east of the well head. Two wastewater tanks, Tanks 1102 and 1103, stored wastewater prior to injection. The tanks were located on the Unit 1100 concrete pad, which was surrounded by a 3-foot high concrete wall. The concrete pad drained to the Unit 1100 sump. Two filter systems were installed to filter wastewater prior to injection.

WDW-138 has passed the most recent mechanical integrity tests (Sandia 2004).

2.3.11 Injection Well WDW-73

Injection well WDW-73 is part of the Unit 700 area (Figure 2). Filtered wastewater was injected for disposal at a subsurface interval of 4650 to 5300 feet in the Miocene Sands.

Brine water for maintaining a positive pressure differential was stored in a small tank located with a concrete containment area near the well. Piping to the well was located over concrete pads. The well was located on a concrete pad, which was recessed eight inches below the surrounding concrete pad.

Three filter systems, two filter pumps and three injection pumps were located at Unit 700. Two filter pumps transferred wastewater in the Unit 700 area to the three filters. Two open-topped, gravity sand filters were located on a concrete pad surrounded by a 2-foot high concrete wall. The third filter was a closed top, gravity sand system designed for filtering odorous wastewater. Spent filter media was disposed of in the Unit 100 API separator.

In addition, the unit contained a transfer sump at Tank 700. The sump collected spilled material during transfers in and out of Tank 700. The sump was constructed of 6-inch thick concrete with one side 3-feet high and the opposite side 8-inches high. The capacity of the sump was approximately 100 gallons. Material collected in the sump was vacuumed and transferred to the Unit 100 API separator.

Five storage tanks were associated with the unit. Tanks 704, 705, 709 and 710 were located within a curbed concrete pad that drains into the Unit 700 sump. Tank 700 was located approximately 100 feet south of the Unit 700 pad. Tank 700 was placed on a raised concrete pad with natural clay containment.

2.3.12 Buildings, Utilities and Wells

In addition to tanks and structures associated with the facility operations, several buildings remain at

the MSC Superfund Site, including the office, shop, and laboratory building (Figure 2). Other buildings include the weight room, two buildings located between Unit 700 and Unit 400, and a small office located near the Unit 1100 injection well.

Small equipment was cleaned and repaired in the maintenance shop. Two drums of recyclable cleaning solvents were provided by Safety Kleen to clean the small equipment.

Five septic tanks were located in the facility in the following locations (Dillard 1981a):

- Unit 1100 – adjacent to small office and pump house
- Unit 900 – one behind the building labeled restroom and one behind the building labeled lunchroom (former laboratory septic tank)
- Shop – south side (back) of shop
- Office – adjacent to building on west side

In addition, three laboratory waste holding tanks were located on the west side of the laboratory.

Two stormwater discharge sumps are located on the northern side of the facility. Each sump contains a plate that can be lowered to block the discharge. The sumps have large hand screw operated flapper-gates that can be closed manually to prevent water flow in either direction. The sumps are connected to the stormwater outlet that discharges through the flood protection levee into the marshy area between the MSC Superfund Site and Swan Lake.

Monitoring wells, MW-01 through MW-20, and MW-24, were field verified by URS during site visits conducted in March 2004.

A water well is located in Unit 700. According to available information, this well was not used as a drinking water source during facility operations (TNRCC 1998) and is currently not used as a drinking water source.

2.3.13 Decanning Area

In August 1981, Malone Services Company notified the TCEQ of the intent to process approximately one million gallons of Silvex (Dillard 1981b) by shredding the containers, allowing the Silvex to flow into a surge tank prior to transfer to a bulk storage tank. The shredded containers would then be triple rinsed through a series of rinsing baths and then loaded into a dumpster box prior to disposal in a Class 1 landfill. The decanning process area was designated in the northeast portion of the facility (Figure 2), east of the Tank 800 area and north of Unit 1100 (ECA 1989a). The 1996 NOR lists three tanks (105 through 107) as decanning unit tanks. The tanks were inactive on the 1996 NOR (TNRCC 1996). It is unknown at this time whether the decanning process was ever constructed or operational.

2.3.14 Cemetery

The Campbell Bayou Cemetery is located on the property, between Unit 900 and the Oil Pit (Figure

2). The cemetery, which served the settlers of Campbell Bayou, is mentioned on a historical marker located near Interstate 45. Reportedly, James and Mary Campbell settled on a one-third league of land (1,476 acres) on Campbell's Bayou at Swan Lake in 1838. Prior to that, the Campbells lived in Jean Lafitte's corsair community of Campeche. James Campbell served Lafitte aboard four different privateers (Block 1991). The Campbells and other residents of Campbell's Bayou are reportedly buried in the Campbell Bayou cemetery.

2.4 Chemical Constituents

Impacts to groundwater were discovered at the MSC Superfund Site in 1979. Subsequently, samples collected in January 1986 from the Unit 100 API separator and the earthen pit exhibited hazardous waste characteristics with numerous organic and inorganic substances being detected. Historical data from sample events conducted from 1986 to 1997 were compiled and submitted in the PSCR (URS 2004a).

2.4.1 Sources of Contamination

The primary sources of contamination identified at the MSC Superfund Site are the earthen impoundment (the Sludge Pit and the Oil Pit) and the Unit 100 API separator (TNRCC 1998). Other potential sources of contamination included the Unit 1200 API separator and the tanks.

As shown in Table 1, metals, such as antimony, arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, thallium, and zinc, were detected in the majority of samples (URS 2004a). Barium was not listed as detected in the tank and container samples, since it was not included on the removal action analyte list. However, barium was reported as present in the twenty-one samples analyzed for toxicity characteristic leaching procedure (TCLP) metals (E&E 1999).

The semivolatile organic compounds (SVOCs) detected in the source areas included PAH, phenolic compounds, and phthalate esters. The most frequently detected SVOCs were naphthalene, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, phenol, phenanthrene, 1,2,4-trichlorobenzene, and acenaphthene. Volatile organic compounds (VOCs) detected in the impoundments, separators and tanks included the aromatic and chlorinated hydrocarbons. The most frequently detected VOCs were total xylenes, ethylbenzene, tetrachloroethene, toluene, 1,1,1-trichloroethane, styrene, trichloroethene, and benzene (URS 2004a).

2.4.2 Groundwater

Total dissolved solids (TDS) concentrations in samples collected from the MSC Superfund Site monitoring wells have ranged from 1624 mg/L in MW-24 to 20,026 mg/L in MW-05 (MSC 1994b). These concentrations indicate that the groundwater in the sand channel would not be considered potable water. The lower TDS concentration in MW-24 may be indicative of the influence of the Freshwater Pond on groundwater in the southwest portion of the MSC Superfund Site.

Table 2 summarizes the groundwater constituents and maximum concentrations detected in groundwater at the site. Historical data indicate that groundwater in the vicinity of four wells adjacent to the earthen impoundment and Unit 100 API separator have been impacted by releases from the sources. These wells are located in the paleochannel adjacent to the Sludge Pit. Wells located at the boundary of the facility and wells located around the Unit 1200 API separator have little or no detections of organic compounds. The wells located around the Unit 1200 API separator are completed outside the paleochannel. The most comprehensive groundwater sampling event was conducted by Malone Services Company in January 1994 (MSC 1994b). The analytes detected in wells adjacent to the earthen impoundment were still not detected at the facility boundary as late as January 1997, suggesting that impacted groundwater is confined to the sand channel and has not migrated to the southwest or southeast (URS 2004a).

2.4.3 Soils and Sediments

A soil sample was collected during the 1997 Site Screening Inspection (SSI) (TNRCC 1998) at the base of the berm for the earthen impoundment in an area that appeared to have a seep. Two soil samples within the bermed areas of Tanks 339 and 806 were collected during the E&E removal action (E&E 1999).

Table 3 summarizes the metal, SVOC and VOC analytes detected in the soil and sediment samples from the MSC Superfund Site. As shown on Table 3, the analytical data indicate potential releases to the soils of chlorinated VOCs, polycyclic aromatic hydrocarbons (PAHs), and metals.

Methylene chloride and bis(2-ethylhexyl)phthalate were detected in the background sample. The methylene chloride concentration in the field sample was comparable to the background concentration. Benzene, ethylbenzene, toluene, and total xylenes were detected in the field sample adjacent to the earthen impoundment and in the soil samples collected within the bermed areas of Tank 339 and Tank 806. In addition to the volatile aromatic compounds, 1,1-dichloroethene, 1,1,1-trichloroethene, and trichloroethene, were detected in the tank area soils.

Pyrene was the only SVOC detected in the soil from the earthen impoundment area. Concentrations of pesticides detected in the January 1997 SSI were less than the Region 6 Human Health Medium Specific Screening Levels (USEPA 2004a). Phthalate esters and PAHs in the Tank 339 and Tank 806 soil samples exceeded the Region 6 Screening Levels.

The beryllium, chromium, cobalt, copper, lead, nickel, vanadium, zinc and cyanide concentrations in the impoundment samples were comparable to concentrations in the background soil sample. Arsenic, chromium, and lead concentrations in the soils from the January 1997 TCEQ sample event and the August 1999 E&E sample event exceeded the Region 6 Screening Levels.

Two Swan Lake locations near the MSC Superfund Site were characterized during the ecological risk assessment (ERA) for the TexTin Superfund Site. One location was used as a reference for illustrative purposes, while the other location had the lowest concentration of chemicals of potential concern and,

consequently, was selected as the habitat reference for the TexTin ERA. With the exception of arsenic, copper, lead, tin and zinc, the concentrations of metals were higher in Galveston Bay than in the southern portion of Swan Lake, that is the area tested by TexTin nearest the MSC Superfund Site. Analytical results were compared to literature values for adverse effects for the benthic macroinvertebrate community. Based on a comparison to literature values, the TexTin risk assessment concluded that the Swan Lake benthic community did not appear to be at risk from the copper, mercury, nickel, and zinc concentrations detected at the TexTin reference location, near the MSC Superfund Site (USEPA 1998a).

Acetone, carbon disulfide, methylene chloride, toluene, bis(2-ethylhexyl)phthalate and PAHs were detected in the background sediment samples collected by the TCEQ during the SSI (TNRCC 1998). This background sample data was used by the TCEQ to evaluate potential releases from the MSC Superfund Site.

Two sediment samples were collected from drainage ditches located within the facility (TNRCC 1998). These samples contained benzene, ethylbenzene, toluene and total xylenes (BTEX), PAHs, phthalate esters, as well as the chlorinated hydrocarbons, hexachlorobutadiene, hexachlorobenzene, 2-chloronaphthalene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and 1,2,4-trichlorobenzene. Chlorinated pesticides were reported present in one sample but pesticides and PCBs were not detected in the other on-site sediment sample. The concentrations of barium, beryllium, cobalt, lead, manganese, nickel, and vanadium reported for the two on-site samples were comparable to the range of concentrations detected in background samples. The concentration ranges for antimony, arsenic, cadmium, chromium, copper, and zinc were greater in the on-site drainage ditch samples than in the background samples. The sediments and soils in the MSC Superfund Site ditches were cleaned, scraped and/or excavated as part of the EPA's emergency responses, and the materials disposed of off-site (Zehner 2004).

Eight sediment samples were collected from outside the flood protection levee in the marshy area. Samples were collected from the drainage channel parallel to the north levee, and along the shorelines of Swan Lake, Campbell Bayou, and Galveston Bay. Acetone, carbon disulfide, methylene chloride, 2-butanone, and bis(2-ethylhexyl)phthalate were detected in these samples at concentrations comparable to the background samples. Other phthalate esters, di-n-butyl phthalate, di-n-octyl phthalate and diethyl phthalate were also detected in some of the samples. Total PAH concentrations in the eight sediment samples ranged from 0.067 mg/Kg to 0.945 mg/Kg and PCBs (Aroclor 1248, 1254 and 1260) were detected in four sediment samples. Trace detections of pesticides were reported for four samples. The concentrations of antimony, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, and zinc in the off-site samples were greater than the range of concentrations in the background samples and in the TexTin reference samples. The maximum detections were generally in a sample located in the small drainage channel in the marshy area adjacent to the MSC Superfund Site and north of the stormwater discharge.

The following are indicated from the sediment data:

- On-site impacts from selected metals, aromatic VOCs, chlorinated hydrocarbons, chlorinated pesticides, and PAHs to on-site drainage ditches, which were possibly later addressed by the EPA emergency response team's removal of ditch sediments/soils.
- Potential impacts to the off-site marshy area adjacent to the MSC Superfund Site from selected metals, PAHs, and pesticides.
- A comparison of the metals data from the on-site drainage ditches to the off-site sediments indicates that the antimony, arsenic, cadmium, chromium, copper, and zinc may be attributable to the MSC Superfund Site, but that the lead, mercury, nickel and silver may not be attributable to the MSC Superfund Site.

2.5 Adjacent Land Use

The land surrounding the facility, from Interstate 45 north to Texas City, is zoned for heavy industry. The land directly north and west of the MSC Superfund Site (approximately 200 acres) is owned by GCWDA. The GCWDA Campbell Bayou Facility provides landfill disposal of nonhazardous wastes to area industrial facilities. The former Texas City Municipal Landfill was northwest of the MSC Superfund Site. The remaining land surrounding GCWDA and the MSC Superfund Site was owned by the University of Texas and, as of February 2, 2004, was sold to Scenic Galveston, Inc. Scenic Galveston is a non-profit organization with the goal of creating a high visibility marsh preserve along the highway approach to Galveston Island. The Monsanto South 20 site, a closed pre-RCRA landfill, is directly adjacent to the MSC Superfund Site to the southeast.

The MSC Superfund Site is located approximately two miles south of the Texas City Industrial Complex, which includes several oil refineries, oil tank farms, chemical plants, loading docks, shipyards, municipal and hazardous waste landfills, and the TexTin Superfund site. In addition to industrial activities, the area has numerous oil and gas wells.

No residents live within one mile of the site. The nearest residential center to the MSC Superfund Site is Bayou Vista, approximately 1.5 miles to the southwest across Interstate 45 along State Highway 6 (Figure 1). A residential section of Texas City is approximately four miles north of the MSC Superfund Site.

2.6 Meteorology

The MSC Superfund Site is located in the warm, moist Texas Coastal Zone. Temperatures range from a January minimum of 43°F to a summer average maximum of 94°F. Between 1931 and 1960, the average annual air temperature in the Houston-Galveston area was about 70°F (University of Utah 2004). The prevailing winds, from the southeast, blow from the MSC Superfund Site towards the Texas City Industrial Complex (Kearney 1989).

Annual rainfall near the MSC Superfund Site ranged from 35 to 74 inches from 1964 to 2002, with an average annual rainfall of 50.6 inches. Annual lake surface evaporation ranged from 38 to 58 inches in the same period, with an average annual evaporation rate of 48.0 inches (TWDB 2004). Since 1964, the Galveston-Houston area has been adversely affected by several major tropical storms and hurricanes. The 24-hour rainfall record (43-inches) for the continental United States was recorded in Alvin, Texas during Tropical Storm Claudette in 1979 (NOAA 2004a). Alvin, Texas is located approximately 20 miles west of the MSC Superfund Site. Since 1957, only one tropical storm or hurricane made landfall on the Texas Coast with a storm surge exceeding the height of the flood protection levee surrounding the MSC Superfund Site. A maximum storm surge of 22 feet was recorded during Hurricane Carla in 1961 (E&E 1999).

Rainfall runoff collected within the waste management areas was disposed through deep well injection. Stormwater collected from the undeveloped areas was reportedly routed to a control retention area then pumped outside the flood protection levee through a discharge outfall along the north levee to Swan Lake/Galveston Bay (MSC 1994a).

The Federal Emergency Management Agency (FEMA) Flood Rate Insurance Map for Texas City, Texas shows the area south of Texas City and east of Highway Loop 197 located within the 100-year flood plain (FEMA 2004). A flood protection levee completely surrounds the MSC Superfund Site (and the waste management units). The levee was built with an average crest elevation of 5.5 m (18 ft) above msl, and with an average elevation of approximately 3 m (9 ft) above msl around the undeveloped area in the northeast corner of the MSC Superfund Site (TNRCC 1998).

2.7 Geology and Hydrogeology

The MSC Superfund Site is located within soils of the Ijam-Urban land complex, that consists of nearly level, poorly drained, moderately saline, clayey soil with a clayey subsoil and Urban Land. Typically, these soils have a surface layer that is calcareous, dark grayish brown clay about 12 inches thick. The upper part of the underlying material, to a depth of 40 inches, is dark gray clay. The lower part, to a depth of 60 inches, is gray clay. The soil is moderately saline and moderately alkaline throughout. The Urban Land consists of soils that have been altered or obscured by buildings, sidewalks, parking lots and wharves. The soils in this complex are very slowly permeable. Surface runoff is very slow and the soils are rarely flooded by storm tides.

Soils adjacent to the MSC Superfund Site on the east and northeast and in areas along the shore of Swan Lake and Galveston Bay are included in the Follet Loam. This soil is a nearly level, poorly drained, saline, loamy soil that has a loamy subsoil located in broad tidal marshes. Typically the surface layer is a mildly alkaline, gray loam, about eight inches thick. The upper part of the underlying material to a depth of 40 inches is a moderately alkaline, light gray loam. The lower part to a depth of 60 inches is moderately alkaline, light gray clay loam. The surface water runoff is very slow. The high water table allows for very little water movement through the soil. The soil remains saturated

throughout the year and is covered with two to twelve inches of water during high tides (USDA 1988).

The MSC Superfund Site is located on the Gulf Coastal Plain in Southeast Texas. The stratigraphic units that underlie the Texas coastal plain and form the principal hydrogeologic units from oldest to youngest include: the Fleming Formation of Miocene age; the Goliad Formation of Pliocene age; the Willis Formation, Bentley Formation, the Montgomery Formation, and the Beaumont Formation of Pleistocene age; and the alluvium of Quaternary age. Collectively, these sediments attain a thickness in excess of several thousand feet along the coastline and consist primarily of interbedded sands and clays with subordinate beds of silt and gravel. Regionally, these stratigraphic units dip toward the Gulf of Mexico and tend to thicken progressively deeper basinward (Baker 1986). The two principal hydrogeologic units that supply fresh water to Houston-Galveston area including Texas City are the Evangeline aquifer and the Chicot aquifer (Carr et. al., 1985).

Surface outcrops in southeast Texas generally parallel the coastline, with older formations found progressively inland. The MSC Superfund Site is located on outcrops of the Beaumont Formation that covers most of Galveston County. The Beaumont Formation consists of fluvial and deltaic sediments including low permeability clays interbedded with more permeable discontinuous silt and sand lenses. These sediments include stream channel and point bar, natural levee, backswamp, and, to a lesser extent, coastal marshes and mud flat deposits (Aronow and Barnes 1982).

The shallow subsurface strata beneath the MSC Superfund Site primarily consists of an upper fine sandy to silty clay underlain by a low permeability, stiff red or gray clay to a depth of at least 40 to 45 feet below ground surface (bgs) (SWL 1979; Law 1982; MSC 1994b). The hydrogeology in the immediate vicinity of the MSC Superfund Site is dominated by a prominent buried paleochannel that meanders southeast from Highway Loop 197 toward Galveston Bay and forms a wide arch beneath the MSC Superfund Site from the southwest to the southeast. A smaller distributary channel bifurcates from the main channel near the center of the MSC Superfund Site and trends to the north-northeast to Swan Lake. The surface expression of the buried paleochannel is evident on early aerial photographs by variations in soil type and vegetation.

The buried paleochannel consists of a fairly uniform tan, very fine-grained, silty sand with an upper boundary found at about 10 feet bgs and a base at about 30 feet bgs on top of the red clay. The width of the buried paleochannel varies from about 200 to 1000 feet. Horizontal field permeability values for the paleochannel aquifer range from 10^{-5} to 10^{-3} cm/sec, and laboratory permeability values on samples of the paleochannel silty sands ranged from 10^{-6} to 10^{-4} cm/sec. Laboratory permeability values for samples of the surrounding fine-grained sediments ranged from 10^{-9} to 10^{-6} cm/sec. Groundwater flow in the sand channel aquifer is variable, primarily controlled by the recharge pattern in the Freshwater Pond to which it is hydraulically connected. Additional hydraulic boundary conditions potentially influencing groundwater movement include liquid and sludge stored in the earthen impoundment, tidal influences from Swan Lake/Galveston Bay, and the closed Monsanto South 20 site downgradient of the MSC Superfund Site. Groundwater flow velocities calculated using

available hydrogeologic data vary from 0.84 ft/yr to 44 ft/yr (MSC 1994a).

The major limitation in the subsurface stratigraphy beneath the MSC Superfund Site is the absence of geologic data below 40 to 50 feet bgs. One groundwater supply well was reportedly drilled in 1968 to a depth of 750-ft bgs and screened across a sand interval between 700 and 750 feet bgs. A second well installed in 1975 to a depth of 200-ft bgs and screened across a sand interval between 185 to 198 feet had poor water quality (TWC 1991). A thick clay interval more than 100 feet thick reportedly separates the buried paleochannel sand aquifer from the lower sand aquifer (MSC 1994a). Stratigraphic information from the adjacent GCWDA facility shows a 4-foot thick sand and silt zone at a depth of 88 feet bgs. It is unknown whether this permeable unit is laterally extensive beneath the MSC Superfund Site.

2.8 Ecological Setting

The MSC Superfund Site is located adjacent to the south shore of Swan Lake and the western shore of Galveston Bay (Figure 1). Swan Lake and the western shore of Lower Galveston Bay are separated by a series of intermittent north-south trending sediment banks or islands (now supplemented with intermittent rock jetties as part of the TexTin Superfund Site OU-4 Remedy), that connect through Campbell Bayou and other shallow channels as part of the larger Galveston Bay System. Lower Galveston Bay is designated as Texas Water Quality Segment 2439 of the Texas Bays and Estuaries. The Lower Galveston Bay Segment is connected with Texas Water Quality Segment 2421 (Galveston Bay), Segment 2422 (Trinity Bay), Segment 2423 (East Bay) Segment 2424 (West Bay), and the Gulf of Mexico (TNRCC 2000). The Galveston Bay system, the seventh largest estuary in the United States, is designated as a National Estuary as part of the National Estuary Program (GBNEP 1992).

2.8.1 Galveston Bay

Galveston Bay is a highly productive nursery for oysters, bay shrimp and sport fish. Approximately 7,000,000 pounds of seafood were harvested from the Galveston Bay System (GBNEP 1992). Galveston Bay provides habitat for brown shrimp (*Penaeus aztecus*), a species economically important to the region.

Rainfall runoff discharge and groundwater to surface water discharge from the MSC Superfund Site enter Texas Water Quality Segment 2439 – Lower Galveston Bay (TNRCC 2000). The Lower Galveston Bay segment encompasses approximately 140 square miles. Water quality is considered limited based on restricted oyster harvesting. Designated water uses for the Lower Galveston Bay segment include aquatic life use, contact recreation use, general use, fish consumption use, and oyster waters use (TNRCC 2000). A Total Maximum Daily Load (TMDL) assessment for bacteria is underway for Segment 2439 with a projected completion date of 2008 (TNRCC 2002; TCEQ 2003).

There are no known or suspected surface water drinking intakes located in the Lower Galveston Bay segment. Several industrial surface water intakes are located in the Texas City area. One permitted

surface water intake is located at the Texas A&M University Galveston Experimental Laboratory on Pelican Island. Surface water withdrawn through this intake is used to water saltgrass. There are six domestic and sixteen industrial outfalls permitted for wastewater discharge into Segment 2439 (TNRCC 1998).

2.8.2 Swan Lake

The depth of Swan Lake ranges to approximately three feet (NOAA 2004b) and the substrate consists of varying depths of semiconsolidated, fine-grained organic mud overlying a firm clay substrate (USEPA 1998a). The prevailing water movement through Swan Lake is from the south to the north (Park 1995). Data gathered during investigations of the TexTin Superfund site (Park 1995; USEPA 1998a), showed the highest concentration of metals tended to be detected in the northern portion of Swan Lake, thus supporting either that the general trend for transport of materials in the lake is to the north and/or the sources of these metals are in the north of Swan Lake. The free exchange of water between Swan Lake and Galveston Bay was accepted as a justification for not considering surface water quality in the TexTin ERA (USEPA 1998a).

2.8.3 Site Habitat

Swamp and marshlands are located directly adjacent to the MSC Superfund Site on the east and northeast, extending to the shore of Swan Lake and Galveston Bay and to the south. Approximately 1.61 miles (8500 feet) of wetlands frontage is adjacent to the MSC Superfund Site (TNRCC 1998). The Swan Lake/Galveston Bay wetlands encompassed by these locations are classified as both estuarine, intertidal, unconsolidated shoreline, irregularly exposed (E2USM) and estuarine, intertidal, emergent, persistent, regularly flooded (E2EMIN). Wetlands are also identified along the shell islands between Swan Lake and Galveston Bay. The National Wetlands Inventory Map for the Virginia Point quadrangle classifies the swamp/marsh land adjacent to the MSC Superfund Site as being intertidal, estuarine, unconsolidated shore, irregularly exposed lands and intertidal estuarine, emergent, persistent, regularly flooded lands. These areas follow the shoreline of Swan Lake and southeast and south along the shoreline of Galveston Bay to Virginia Point. The MSC Superfund Site area and areas adjacent to the site to the north, west and south are shown as being primarily uplands (USDOI 1992).

The MSC Superfund Site is surrounded by a flood protection levee with only two potential off-site migration routes. The first of these routes is the vehicle gates located in the southwest and southeast corners of the MSC Superfund Site. The second outlet is a sealable stormwater gate and drainage pipe extending through the flood protection levee on the north side of the MSC Superfund Site.

The on-site Freshwater Pond contains an undetermined number of species of fish, numerous waterfowl (mostly seasonal), and an alligator (TNRCC 1998).

The probable point of entry (PPE) from the groundwater to surface water migration pathway is the shortest straight-line distance within the aquifer boundary from the source at the MSC Superfund Site to the surface water (TNRCC 1998). The PPE for the MSC Superfund Site is the northern tributary

of the paleochannel crossing beneath the site where it enters Swan Lake and Galveston Bay. The distance from the earthen impoundment to the PPE is approximately 1250 feet. The eastern branch of the paleochannel extends to the southeast to Galveston Bay. The location where the eastern branch enters the bay is unknown.

2.8.4 Wildlife

Shorebird, songbird, waterfowl and raptors are known to migrate, winter and breed along the Texas Coast. These include federal and state endangered *Pelecanus occidentalis* (Brown Pelican), federal and state endangered/threatened *Falco peregrinus* (Peregrine Falcon), federal and state threatened *Charadrius melodus* (Piping Plover), and state threatened *Egretta rufescens* (Reddish Egret) and *Plegadis chihi (*White-faced Ibis). The Texas Colonial Waterbird Society has designated the Swan Lake Bird Rookery the shell islands that serve as a breeding ground for various gulls (subfamily Larinae), various herons and egrets (family Ardeidae), the Gull-Billed Tern (*Gelochelidon nilótica*), the Forster's Tern (*Stérna fórsteri*), and the Black Skimmer (*Rynchops nigra*) (USEPA 1998a). Within a 4-mile radius of the MSC Superfund Site, at least one Migratory Songbird Stopover Fallout site (Moody Ranch) has been identified. Fourteen bird rookeries have been identified within the 4-mile radius.

The Texas Parks and Wildlife Program, Texas Biological and Conservation Data System has listed five federal and state endangered species, one federal threatened and state endangered species, two federal and state threatened species and two state threatened species within a four-mile radius and 15-mile downstream distance of the MSC Superfund Site (TNRCC 1998). These endangered and threatened species include the Leatherback Sea Turtle (*Dermochelys coriacea)*, the Atlantic Hawksbill Sea Turtle *(Eretmochelys imbricata imbricata)*, Kemp's Ridley Sea Turtle *(Lepidochelys kempii)*, the Loggerhead Sea Turtle *(Caretta caretta)*, and Green Sea Turtle *(Chelonia mydas)*

2.9 Remedial Responses

Several closure plans have been developed in the past for the MSC Superfund Site, primarily to address the Sludge Pit and Oil Pit. These plans were not implemented or partially implemented for various reasons. These previous closure plans are discussed below.

As part of the pre-RCRA corrective action, Malone Services Company proposed a cap and a slurry wall for the closure of the impoundments (Law 1982; ECA 1989a). It was proposed that the impoundments would be covered with permeable and impermeable liners and capped with soil. The weight of the soil cover would force liquids out of the impoundments and into the adjacent sand channels where the liquids would be recovered and treated. The surface of the pit would then be graded to the present berm height. An impermeable slurry wall would be installed down-gradient from the Sludge Pit to seal the sand channel from further contaminant migration (Kearney 1989).

As part of a Compliance Agreement with the TCEQ in January 1983, Malone Services Company began

closure of the Sludge Pit and the Oil Pit. Considerable quantities of sand were placed in the eastern one-third and southwestern corner of the Sludge Pit and over the Oil Pit contents. Geotextile fabric was installed to cover the impoundment contents in both the Sludge Pit and the Oil Pit. Part of the closure actions performed by Malone Services Company on the impoundment included the installation of perimeter extraction wells and settlement gauges around both the Sludge Pit and the Oil Pit. A leachate collection system was also installed around the perimeter of the impoundment (ECA 1989a) to recover water leaching up through the sand and geotextile.

The approval of the closure plan was voided by the Attorney General's office on April 2, 1986 (Capitan 1989). Several months after closure activities ceased, the geotextile fabric in the Sludge Pit tore, thereby allowing waste material to flow to the top of some of the sand in the eastern one-third of the sludge pit. According to Environmental Consulting Associates (ECA) (ECA 1989a) the southwestern corner of the Sludge Pit is depressed, which allows rainwater to collect. There has also been substantial settling of the surcharge material in the Oil Pit (ECA 1989a). URS's observations are that currently the entire Sludge Pit is topped with water with only some floating geotextile material emergent at one small location near the west central end of the impoundment. During prolonged periods of low precipitation, the underlying sludge may be uncovered by water.

On March 1989, ECA submitted a FS and closure plan for the earthen impoundment on behalf of Malone Services Company to TCEQ for review (ECA 1989a). A request for authorization to perform pilot studies was also submitted as part of the closure plan. The closure alternatives evaluated by ECA included:

- no action;
- containment using a liner or cap;
- treatment methods including incineration, biological/aeration, solidification, and dewatering; and
- disposal methods including deep well injection and landfill burial.

After evaluating the closure alternatives, ECA recommended a closure plan that included three treatment steps:

- aeration/biodegradation
- dewatering
- solidification

The aeration/biodegradation phase of the plan proposed the installation of surface aerators and continually aerating the waste material with periodic additions of a microbial culture and water to promote biodegradation of the waste. During the dewatering phase, the aerated waste material would be pumped into a settling basin and subjected to a mechanical consolidation process to reduce the overall waste volume. The consolidation process was to be performed by continually mounding and

remounding the waste material using a crane mounted dragline bucket. The liquid waste from the treatment would be disposed of on-site in the permitted deep well injection facility. In the final phase, ECA proposed solidification of the remaining sludge with a 10% to 20% mixture of fly ash. The solid residuals from the treatment would be disposed of in a capped and lined at-grade landfill. A synthetic membrane liner would also be incorporated into the plan to provide storage and curing space for the solidified waste material and to act as a barrier for further migration of the waste off-site. A low permeability clay cap would be placed over the impoundment (ECA 1989a).

A treatability study on aeration/biological degradation and aeration/settling for the impoundment waste was also included in the Draft Feasibility and Closure Plan (ECA 1989a). Waste sample and water mixtures were used for the aeration/biological degradation study. The waste sample was obtained from the Sludge Pit at three different depth intervals, which were assumed to be representative of the upper, middle, and lower portions of the waste. The samples were then placed in tanks and aerated with diffused air aerators. A microbial culture was added to each of the tanks after aeration began. The results indicated that aeration and biological degradation were effective in reducing the Chemical Oxygen Demand (COD) concentrations by 60% after 14 days and 80% after 35 days. There was no difference in response between the upper, middle, and lower zones of the waste material.

For the aeration/settling study, the waste samples obtained from the same depth intervals as the biodegradation study were mixed with water, aerated for different specified aeration intervals, and allowed to settle quiescently. The settling characteristics of each of the samples were measured visually. Volume reductions of 15% to 40% in the solid waste were observed. The upper zone benefited the most from aeration/settling compared to the middle and lower zones. These studies are not considered accurate by URS for the proposed treatability purposes because they did not test the settleability of sludge previously treated by biodegradation, as outlined in the treatment sequence. URS's concerns with the test methods does not indicate a conclusion that the outlined treatment process could not work, but that the testing was not done appropriately to demonstrate the true outcome.

The TCEQ reviewed the FS and closure plan and responded (TWC 1989) with several concerns regarding the closure plan:

- compliance with "Land Ban" restrictions;
- lack of data on the waste streams;
- liner strength;
- cap design; and
- performance standards (remedial action objectives).

The proposed closure plan involved the removal, treatment, stabilization, and placement of waste back into the impoundment. The agency felt that the removal, treatment, and placement of the waste

invoked the "Land Ban" restrictions, which prohibit the redeposition of treated wastes into units from which they were removed. The TCEQ stated that Malone Services Company would have to either petition EPA for an exemption, waiver, or variance or obtain authorization from EPA that the proposed treatment would meet all applicable federal regulatory standards.

The agency was also concerned with the lack of information on whether the characteristics of the waste stream would limit microbial degradation of the wastes during the aeration/biodegradation treatment process and that some of the unsolidified waste material could potentially contaminate the groundwater. The agency questioned if the 20-ml HDPE liner proposed by ECA could withstand the tensile stress of the waste material and weight of construction equipment. The closure plan did not provide sufficient technical information for the cap design and installation. Preliminary calculations performed by the agency indicated that the proposed cap design did not meet the agency technical guidelines for capping hazardous waste landfills. The TCEQ noted that no performance standards were given for all the treatment processes specified in the proposed closure plan.

The agency authorized the performance of pilot studies by ECA to determine in-situ aeration equipment and air requirements and to optimize the aeration, dewatering, and solidification processes. Data for the pilot studies have not been located by URS.

On February 8, 1993, Malone Services Company submitted a submitted a proposal for the use of a closed system thermal treatment unit in the closure of the earthen impoundment (TWC 1993). This thermal unit reportedly would volatilize and capture the alcohols [*sic*] in the waste and allow the separation of aqueous, oily, and solid phases of the waste. The solid phase would be stabilized and disposed of, while the oily phase would be used to fuel the thermal unit, and the aqueous phase would be injected into a deep injection well. TCEQ approved this closure proposal on March 12, 1993 and requested a formal closure plan. Data supporting this process have not been located by URS.

The Superfund Technical Assessment and Response Team (START) conducted an emergency response action in April and May 2000. Approximately 1,767,196 gallons of material were removed from the tanks with approximately 1,987,807 gallons of solids and sludge remaining in the tanks. In addition, WDW-138 was rehabilitated during November 1999 using a well cleanout and acid wash (E&E 2000). Approximately 3,227,867 gallons of tank liquids and stormwater were disposed of in the well between December 1999 and May 2000.

A filter press was designed and installed to dewater sludge in Unit 1200 (E&E 2000). Attempts to dewater the sludge with various amendments were unsuccessful and the operation was terminated in January 2000. The lime-sludge mixture of about 30 – 35% originally formulated for dewatering the sludge had to be reformulated because the composition of sludge in the four cells of Unit 1200 were different. Pre-treatment methods were evaluated for enhancing solid filter cake production from dewatering the sludge, including ferric chloride, ferric sulfate and diatomaceous earth, and the installation of a boiler and steam heat system. These methods proved ineffective.

Approximately 450 cubic yards (yd^3) of material were dewatered in Unit 1200 during the process. The

loose solids in the Unit 1200 drying pit were solidified in-situ with lime and 29 roll-off boxes of filter press wastes were sent to a Class 1 non-hazardous landfill in March 2000 (E&E 2000). The sludge remaining in the other cells was redistributed and the surface liquid was pumped into an oil-water separator to allow suspended solids to settle. The separated liquid was injected into the deep well. The solids were returned to Unit 1200. The filter press units and associated equipment were decontaminated, dismantled, and demobilized by February 2000.

Approximately 2,025 yd^3 of sludge were dewatered in the Unit 100 surface impoundment using a 30% mixture of quicklime. The solids were placed on-site, covered with a plastic liner and surrounded by a one-foot high clay berm (E&E 2000). The earthen containment around T804, which had high levels of petroleum hydrocarbons, was solidified in-place with lime. Data on the success of this treatment was not provided in the removal assessment report.

START was also tasked by the USEPA Region 6 Response and Prevention Branch to conduct removal assessment activities at the MSC Superfund Site (E&E 1999). START inventoried the laboratory contents, the contents and condition of 85 buckets and cans and 34 drums. Container samples were screened using field hazard categorization (HAZCAT) techniques to identify potentially RCRA hazardous materials. The team documented the presence of 117 aboveground storage tanks; 31 contained a total estimated volume of 4.1 million gallons of waste materials. The remaining tanks reportedly were empty.

START reportedly also removed sediments/soils from the drainage ditches and disposed of this material off-site (Zehner 2004).

3.0 CONCEPTUAL SITE MODEL

This section discusses the potential exposure pathways and describes the development of the conceptual site model for the MSC Superfund Site. The conceptual site model conveys what is known about the sources, releases, release mechanisms, contaminant fate and transport, exposure pathways, potential receptors and risks. Data collected during the RI will be used to verify and/or augment the model. The remedial action objectives are developed from the pathways and receptors identified in the conceptual site model.

Exposure pathways describe the environmental transport mechanisms by which potential receptor populations may contact chemical constituents present, or originating, from a site. An exposure pathway requires four necessary elements:

- A source and a mechanism for chemical releases to the environment (primary and secondary sources and release mechanisms).
- An environmental transport medium for the released chemical.
- A point of human or ecological contact with the medium.
- A human or ecological uptake route (ingestion, inhalation, or dermal contact) at the point of exposure.

Potential exposure pathways for the MSC Superfund Site include:

- Incidental ingestion of surface soil;
- Incidental ingestion of sediment;
- Incidental ingestion of surface water;
- Ingestion of fish from Swan Lake;
- Dermal contact with surface soil;
- Dermal contact with sediment;
- Dermal contact with surface water;
- Inhalation of volatile emissions from groundwater; and
- Inhalation of volatile emissions from surface and subsurface soil.

Exposure pathways for the sludge contained within the earthen impoundment were not developed since the sludge is covered with water and direct human and ecological exposure is unlikely. Exposure to the surface water covering the sludge is likely for ecological receptors and will be considered in the surface water exposure pathway development.

The evaluation of a specific exposure pathway is based on contaminant mobility and behavior in the various affected media, as well as the release and migration mechanisms for the potential chemicals

of concern (COCs), as discussed below.

3.1 Contaminant Mobility and Behavior

Potential COCs at the MSC Superfund Site can be released to air, soil, surface water, and groundwater. Data for the MSC Superfund Site groundwater, soils and sediments demonstrate releases from the site sources of aromatic and chlorinated VOCs, PAHs, and metals. Tables 1 through 3 include the maximum concentrations detected in wastes, groundwater and soils at the MSC Superfund Site. Analytical data for sludge in the impoundments indicate the presence of volatile and semivolatile organic compounds in concentrations ranging from 30 to 5000 mg/Kg. Groundwater concentrations of volatile and semivolatile organic compounds range from 0.050 to 2600 mg/L.

The chlorinated and aromatic VOCs and phenolic SVOCs exhibit high (>500 mg/L) solubilities. The other SVOCs generally have low to moderate solubilities in water (10 to 500 mg/L). The relatively high solubilities of the chlorinated and aromatic VOCs indicate that these compounds will preferentially dissolve into aqueous phases and be readily transported in groundwater. The PAHs generally have solubilities in the part per million range (< 1 mg/L). Vapor pressures for the SVOCs are less than 1 mm Hg, indicating low volatility, while the vapor pressures of the volatile compounds range from 1 to 100 mm Hg. The low vapor pressures and low Henry's Law constants (0.00001 to 0.01) for the semivolatile compounds suggest that volatilization from soil surfaces or from solution, will not readily occur.

3.2 Release and Migration Mechanisms

Transport of the potential COCs in environmental media is a function of the physical and chemical properties of the chemicals, the form in which the potential COCs were released, and the environmental conditions present at the MSC Superfund Site. These environmental conditions consist of a multi-component system at the MSC Superfund Site that includes air (ambient and soil gas), soil (unsaturated and saturated), groundwater, and surface water. The information and data presented in the PCSR are the basis for the conceptual site model (URS 2004a), which is presented visually in Figure 4.

3.2.1 Primary Sources and Release Mechanisms

Three primary sources of potential COCs have been identified at the MSC Superfund Site:

1. the Earthen Impoundment (including both the "Oil Pit" and the "Sludge Pit");
2. the API separators (Units 100 and 1200); and
3. the tanks.

Miscellaneous potential sources, such as the Closed Backwash Pit, the Lay Down area in the northwest corner of the MSC Superfund Site, the distillation unit, the filters and pumps associated with the

injection wells, the laboratory sumps and the decanning area, may have contributed to impacted soil and groundwater, but this is not apparent from current data.

As shown on Figure 4, potential primary release mechanisms from these sources included:

- Infiltration and percolation from the earthen impoundment, the closed backwash pit and the slop oil pits;
- Spills from the loading and unloading of wastes at the earthen impoundment, the API separators and the tanks to the MSC Superfund Site soil;
- Discharges (overtopping) and stormwater runoff from the earthen impoundment;
- Overfilling, spilling and leaking of wastes from process area operations (separators, distillation units, and injection wells) to surface soil;
- Leakage from ancillary piping to surface and subsurface soil; and
- Infiltration and percolation from underground sumps (such as the laboratory sumps).

The earthen impoundment was constructed in the paleochannel that transects the MSC Superfund Site. Wastes placed within the earthen impoundment and other potential sources were released to the groundwater through dissolution or sorption onto fine particulate matter. Once dissolved or sorbed, the chemicals would migrate with the groundwater through the preferential flow in the sand channel.

Potential COCs within the waste liquids and sludge placed in the earthen impoundment, the API separators, and the tanks may have been released to the MSC Superfund Site soil by discharges (overtopping), spills or leaks to surface soil or may have migrated into MSC Superfund Site soil through infiltration or percolation (subsurface soil). Rain and surface-water infiltration through impacted soil leaches the more water-soluble portions of the fluids resulting in the water-miscible fluids mixing with the groundwater and, depending on site characteristics, may migrate laterally.

Potential COCs residing in surface soil (0 - 2 feet), such as in the tank areas may be mobilized and transported by wind erosion, volatilization, or episodic surface runoff. These potential COCs in surface soil may also migrate vertically to subsurface soil by desorption and leaching processes and may potentially enter groundwater.

Potential COCs in the groundwater may migrate by advection and dispersion via groundwater flow, volatilize to soil gas and ultimately disperse into the atmosphere, or become adsorbed to aquifer soils. Advection by means of groundwater flow may redistribute potential COCs to the shallow groundwater environment or transfer them to deeper aquifers. These potential COCs are subject to attenuation by chemical and biological degradation processes. The silt and sand in the vadose zone paleochannel increases the probability of impacted groundwater migration from the source to off-site receptors either in the marsh area between the MSC Superfund Site and Swan Lake or to the east (the Monsanto South 20 site).

3.2.2 Secondary Sources and Release Mechanisms

The primary releases may result in secondary sources: groundwater, on-site surface and subsurface soils and the on-site drainage ditches. Potential secondary release mechanisms from the soils at the MSC Superfund Site include:

- Discharge/runoff to off-site surface water and off-site sediment;
- Runoff from contaminated on-site soils to off-site surface water and off-site sediment;
- Soil leaching to on-site groundwater; and
- Groundwater migration off-site.

The mechanisms for releases from the sources, such as infiltration, percolation, advection and sorption, as discussed above also apply to the secondary sources.

3.3 Exposure Pathways and Receptors

Based on the information provided in the environmental reports and summarized in previous sections, the following potential exposure pathways have been identified at the MSC Superfund Site:

- impacted on-site sediments;
- impacted on-site surface soils; and
- impacted groundwater.

The potential for release of VOCs is high where the waste is potentially exposed to the atmosphere, such as in the Sludge Pit, and the Unit 100 and Unit 1200 API separators. Since the predominant wind direction is from the southeast, the population northwest of the MSC Superfund Site would be the potential receptors of air emissions. The Texas City Industrial Complex is northwest of the MSC Superfund Site.

3.3.1 Soil Exposure Pathway

The Unit 100, Unit 700, Unit 900, Unit 1100 and Unit 1200 areas are constructed on curbed concrete pads. The integrity of these concrete pads is unknown; therefore, the potential for releases to soils cannot be eliminated. The Unit 300, Unit 400, and Unit 800 tanks sit on native soil in areas bermed with native clay. The potential for releases to surface soils in these areas would be high. Depending on the subsurface stratigraphy, release potential to subsurface soils in these units would be low in areas constructed over the impermeable native clay, while the release potential to subsurface soils would be high in areas constructed over the sand channel. Those units, such as the Sludge Pit and the Oil Pit, which are completed in the sand channel, have a high release potential to soils and to groundwater.

3.3.2 Groundwater Exposure Pathway

Concentrations of metals, VOCs and SVOCs in the shallow groundwater bearing-unit indicate that

groundwater has been impacted by releases from the MSC Superfund Site operations. These releases may have occurred from those units located above or within the paleochannel, such as the Unit 100 API separator and the earthen impoundment (the Sludge Pit and the Oil Pit).

No public water supply or domestic drinking water wells have been identified within a one-mile radius of the MSC Superfund Site (TNRCC 1998). One existing well reportedly drilled at the MSC Superfund Site in a deeper aquifer to supply water for site operations is located on the site near the Unit 700 injection well. GCWDA has one active fresh water supply well on-site. Water from this well is not used for drinking water purposes (TNRCC 1998).

3.3.3 Surface Water and Sediment Exposure Pathway

Since the Freshwater Pond was excavated into the paleochannel, variations in the pond elevations correspond to variations in water levels of monitoring wells completed in the paleochannel demonstrating that the Freshwater Pond is hydraulically connected to groundwater. The pond collected stormwater runoff from areas of the facility and potentially may have accumulated contaminants. Contaminated on-site surface soils would drain to the on-site drainage ditches. Discharge/runoff from on-site drainage ditches was (and may currently be) channeled to the Freshwater Pond via the laydown area or to off-site surface water and sediments through the stormwater discharge. If contaminants have accumulated within the pond, they may be released to groundwater and, depending on whether the hydraulic gradient from the Sludge Pit, Oil Pit and Unit 100 API separator is towards the pond, groundwater contaminants may be released to the pond.

3.3.4 Receptors

Figure 4 summarizes the selection of potential exposure pathways for evaluation in the RI/FS for the MSC Superfund Site. Multiple exposure routes for inhalation, ingestion, and dermal contact exist for each of the pathways listed above and for each of the types of receptors (human and ecological).

The potential for exposure to residential receptors was not evaluated in the conceptual site model. It is likely that restrictions on future development at the site, including restrictions against homes, hospitals, schools and day-care centers, will be placed on the property. The location of the MSC Superfund Site in the floodplain and accessibility only through property owned by other entities (GCDWA and Scenic Galveston) preclude future residential development. No on-site residences exist and the closest off-site residential area (Bayou Vista) is approximately 1.5 miles away. Currently, the MSC Superfund Site is inactive. Activities, such as stormwater disposal and security patrol, occasionally occur on-site. Possible future site development, either as an industrial facility or as a nature preserve will potentially require the presence of maintenance workers and/or recreational users. These potential human receptors were included in the conceptual site model.

Complete on-site pathways for human receptors include inhalation of volatile compounds by maintenance workers or recreational users from both groundwater and soil. Ingestion and dermal contact exposure pathways are not considered complete for on-site groundwater exposure to human

receptors. These pathways are not considered complete exposure routes since the on-site water well does not provide potable water and is completed approximately 750-ft bgs. In addition, the TDS data (> 10,000 mg/L) for the shallow groundwater at the MSC Superfund Site and the adjacent Monsanto South 20 site indicate that this water would not be a source of potable water in the future.

Incidental ingestion, inhalation and dermal contact to on-site surface soils, surface water and sediments are considered potentially complete exposure pathways to both maintenance workers and recreational users. Additionally, ingestion of fish is considered a potentially complete exposure pathway to recreational users. The fish ingestion exposure pathway will be evaluated in the risk assessment by calculating hypothetical fish tissue concentrations from the sediment data.

Ecological receptors, both terrestrial and aquatic, are included in the conceptual site model. The location of the facility and the presence of the Freshwater Pond and the marshy area between the MSC Superfund Site and Swan Lake indicates that the potential for exposure of both vertebrate and invertebrate species to site contaminants exists. Ingestion is the considered potentially complete exposure pathway for receptors in the Freshwater Pond and the marshy area.

3.4 Remedial Action Objectives

In order to facilitate the selection of preliminary remedial alternatives, the site has been divided into remedial units. The remedial units were selected based upon the media, the types of contaminants, and the exposure scenario: groundwater, sludge and liquid wastes, on-site soils and sediments, and off-site sediments. The sludge and liquid wastes remedial unit includes material contained within the primary sources, the earthen impoundment, API separators, tanks, pits, and sumps. Structures were not included in the remedial units since they belong to the property owner. Sludge and liquid wastes remaining within structures such as tanks, sumps, or buildings are included in the sludge and liquid waste remedial unit.

Remedial action objectives provide medium-specific (or remedial unit specific) goals for protecting human health and the environment. Using the conceptual site model information discussed above, remedial action objectives were developed for each remedial unit.

3.4.1 Groundwater

The remedial action objectives for groundwater are to:

- Prevent inhalation of carcinogenic and non-carcinogenic contaminants by site workers and recreational users in excess of agreed risk-based cleanup levels;
- Restore groundwater to agreed risk-based cleanup levels protective of ecological exposure to surface water and sediments in Swan Lake; and
- Prevent further migration of the most-contaminated groundwater to off-site properties.

3.4.2 Sludge and Liquid Wastes

The remedial action objectives for sludge and liquid wastes are to:

- Prevent ingestion/direct contact/inhalation of carcinogenic and non-carcinogenic contaminants in excess of agreed risk-based cleanup levels by site workers and recreational users;
- Prevent the release of carcinogenic and non-carcinogenic contaminants in excess of agreed risk-based cleanup levels from sludge and liquid wastes to surface soils and sediments;
- Prevent migration of carcinogenic and non-carcinogenic contaminants from sludges and liquid wastes to groundwater in excess of agreed risk-based cleanup levels for inhalation by site workers and recreational users from groundwater contaminants;
- Prevent the release of contaminants from sludge and liquid wastes to surface soils and sediments in excess of agreed ecological risk-based cleanup levels; and
- Prevent the release of contaminants from sludge and liquid wastes to surface water in excess of agreed ecological risk-based cleanup levels.

3.4.3 On-site Soils and Sediments

The remedial action objectives for on-site soils and sediments are to:

- Prevent ingestion/direct contact/inhalation by site workers and recreational users of carcinogenic and non-carcinogenic contaminants in excess of agreed risk-based cleanup levels;
- Prevent inhalation by site workers and recreational users of carcinogenic and non-carcinogenic contaminants from subsurface soils in excess of agreed risk-based cleanup levels;
- Prevent direct contact/inhalation by site workers and recreational users of carcinogenic and non-carcinogenic contaminants from sediments in excess of agreed risk-based cleanup levels;
- Prevent ingestion (fish) by recreational users of carcinogenic and non-carcinogenic contaminants in excess of agreed risk-based cleanup levels;
- Prevent migration of contaminants to groundwater from on-site soils and sediments in excess of agreed risk-based cleanup levels for the prevention of inhalation of contaminants by site workers and recreational users;
- Prevent ingestion by terrestrial ecological receptors of contaminants from surface soils in excess of agreed risk-based cleanup levels;
- Prevent ingestion by terrestrial and aquatic receptors of contaminants from sediments in excess of agreed risk-based cleanup levels;
- Prevent the ingestion (fish) by terrestrial receptors of contaminants from sediments in excess of agreed risk-based cleanup levels; and

- Prevent migration of contaminants to surface water in excess of agreed ecological risk-based cleanup levels.

3.4.4 Off-site Sediments

The remedial action objectives for the off-site sediments in the marshy area between the MSC Superfund Site and Swan Lake are to:

- Prevent ingestion/direct contact/inhalation of carcinogenic and non-carcinogenic contaminants from sediment by recreational users in excess of agreed risk-based cleanup levels;
- Prevent ingestion (fish) by recreational users of carcinogenic and non-carcinogenic contaminants in excess of agree risk-based cleanup levels;
- Prevent migration of contaminants to groundwater from off-site sediments in excess of agreed risk-based cleanup levels for the prevention of inhalation of contaminants by site workers and recreational users;
- Prevent ingestion by terrestrial and aquatic receptors of contaminants from sediments in excess of agreed risk-based cleanup levels;
- Prevent the ingestion (fish) by terrestrial receptors of contaminants from sediments in excess of agreed risk-based cleanup levels;
- Prevent migration of contaminants to surface water in excess of agreed ecological risk-based cleanup levels; and
- Restore sediments to agreed ecological risk-based cleanup levels.

4.0 INITIAL SCREENING OF COMPARABLE SUPERFUND SITES

This report attempts to evaluate a presumptive remedy for the MSC Superfund Site based on remedies implemented at other USEPA Region 6 Superfund Sites. Applicable information for contaminants, types of units, geology/hydrogeology, and general settings for Superfund sites in Region 6 were evaluated to determine which Region 6 Superfund Sites were comparable to the MSC Superfund Site. For those sites deemed comparable to the MSC Superfund Site, applicable information of considered, proposed, implemented or inappropriate remedial alternatives or technologies were evaluated. Three sites deemed the most comparable to the MSC Superfund Site were further evaluated in a detailed screening of their history, remedial alternative evaluations in the FS and the costs to implement the remedies. This section discusses the initial screening results for the USEPA Region 6 Superfund Sites. The results of the detailed screening are presented in Section 5.0.

4.1 Comparable Sites

Comparable sites include waste sites with similar types of contaminants for which the data, setting, and record may be applicable to the characterization of the MSC Superfund Site and to the selection of appropriate remedial alternatives. Criteria for the initial screening of sites were:

1. Participation in the Superfund Program in USEPA Region 6;
2. Pits or impoundments were part of the source units;
3. Wastes came from petroleum and petrochemical processes;
4. The site was located on or near the Gulf Coast; and
5. A remedy had been selected for the site.

The sites that met these criteria include:

- Bailey Waste Disposal (Bridge City, Orange County, Texas)
- Brio Refining, Inc (Friendswood, Harris County, Texas)
- Dixie Oil Processors Inc (Friendswood, Harris County, Texas)
- Dutchtown Treatment Plant (Dutchtown, Ascension Parish, Louisiana)
- French Superfund Site (Crosby, Harris County, Texas)
- Gulf Coast Vacuum Services (Abbeville, Vermillion Parish, Louisiana)
- Highland Acid Pit (Highlands, Harris County, Texas)
- Mallard Bay Landing Bulk Plant (Grand Cheniere, Cameron Parish, Louisiana)
- MOTCO Superfund Site (LaMarque, Galveston, County, Texas)
- Old Inger Oil Refinery (Darrow, Ascension Parish, Louisiana)

- PAB Oil and Chemical (Vermillion Parish, Louisiana)
- Petrochemical Processors (Turtle Bayou) (Liberty, Liberty County, Texas)
- Petro-Processors of Louisiana (Scotlandville, East Baton Rouge Parish, Louisiana)
- Sheridan Disposal Services (Hempstead, Waller County, Texas)
- Sikes Disposal Pits (Crosby, Harris County, Texas)

The **Bailey Waste Disposal Superfund Site** is located near Bridge City, Orange County, Texas. The site began receiving industrial and municipal wastes in 1950. The site consists of the waste channel, the drum disposal area, the waste pits, and a large surface impoundment constructed in the marsh. Waste was documented on approximately 10 acres of the site with an approximate volume of 156,000 yd^3. Waste had also migrated from the site into the adjacent marsh area. The principal contaminants at the site are metals (including arsenic compounds), benzene, phenols, pyridines, naphthalenes, and chlorinated hydrocarbons. The seasonal high groundwater level is about 5 feet. The contaminated material from the drum disposal area and the drainage channel were consolidated in the waste channel and the consolidated material was capped. Contaminated sediments were taken off-site for disposal in a Class 1 industrial waste landfill. The RI concluded that the site would not have an impact on drinking water since the shallow groundwater is saline and not potable and it would take 800 years for contaminants to reach a drinking water supply in the deeper aquifer (USEPA 2004b).

The **Brio Refining Superfund Site** is located at 2501 Dixie Farm Road in southern Harris County near Friendswood, Texas. Operations began at the site in 1957 and included by-product recycling, copper catalyst regeneration, petrochemical recovery, and jet fuel processing. Contaminants found in on-site pits consisted of styrene tars, vinyl chloride, chlorinated solvent residues, metal catalysts and fuel oil residues. The USEPA estimated approximately 62,000 yd^3 of soil and 40,000 yd^3 of sludge and liquids at the site. Approximately 100,000 gallons of sludge and solids were removed from the tanks. Over 82,000 gallons of dense non-aqueous phase liquids (DNAPL) have also been removed from the site and 25 million gallons of groundwater have been treated. On-site soil and groundwater are contaminated by 1,2-dichloroethene, 1,1,2-trichloroethane, vinyl chloride, fluorene, anthracene, phenanthrene, pyrene and other hydrocarbons, and copper (USEPA 2004c). The original remedy chosen by USEPA and the Brio Site Task Force (BSTF) was on-site incineration of soils and sludge. After technical problems with the remedy, the remedial alternatives implemented at the site include installing a sub-grade vertical barrier wall enclosing the site, capping the site with a cover system, controlling groundwater within the containment system, and improving an adjacent drainage body (Mud Gully) (TCEQ 2004a).

The **Dixie Oil Processors Superfund Site** is located on Dixie Farm Road in southern Harris County near Friendswood, Texas. The site is adjacent to the Brio Refining Superfund Site. The site operated from 1969 to 1978 as a copper recovery and hydrocarbon washing facility. After 1978, Dixie Oil Processors began oil recovery, including cuprous chloride catalyst, hydrocarbon washing, oil washing

and blending distillation residues from local chemical plants. Contaminated soils were removed in an emergency action in 1984. USEPA estimated waste volumes of approximately 118,000 gallons in storage vessels and 107,000 yd^3 of contaminated soil. The site remedy implemented was limited action and monitoring (USEPA 2004d).

The **Dutchtown Treatment Plant Superfund Site** is located at the junction of I-10 and Highway 74 in Dutchtown, Ascension Parish, Louisiana. The five-acre site contained ten storage tanks, a rail car tanker, a 0.07-acre oil pit and a 0.8-acre holding pond containing oil and water. Principal contaminants on the site are benzene, ethylbenzene, toluene, xylene, and lead. Approximately 450,000 gallons of waste oil from the holding pond, oil pit and tanks were shipped off-site for incineration. Approximately 4,500 $yd^3$of soil were treated by soil washing, then stabilized and used as backfill in the holding pond and oil pit. Approximately 3.5 million gallons of stormwater were treated in an on-site water treatment unit. The remedy chosen for groundwater was natural attenuation with contingencies if the groundwater migrated out of the current location (USEPA 2004e).

The **French Limited Superfund Site** is located two miles southwest of Crosby, Texas in northeast Harris County. The site was used for sand mining operations between 1950 and 1965. From 1965 to 1972, the site was permitted by the TCEQ for petrochemical waste disposal. Groundwater contained volatile organic compounds and phenols at 10 ppm. Sludge contained volatile organic compounds (6%), phenols (1%), heavy metals (2%), and PCBs (310 ppm). The waste volume consisted of 8,000 yd^3 of PCB-containing sludge, 68,000 yd^3 of non-PCB sludge, 25,000,000 gallons of groundwater, and 70,000 yd^3 of soil. The original remedy chosen by USEPA for the site was on-site incineration of contaminated soils and sludge. After the French Limited Task Group (FLTG) demonstrated the effectiveness of bioremediation, contaminated soils were treated on-site using in-situ bioremediation process. Groundwater was extracted and treated with biological remediation and carbon absorption prior to discharge to the San Jacinto River. Currently the groundwater treatment system is inoperative and groundwater is monitored for natural attenuation (USEPA 2004f).

The **Gulf Coast Vacuum Services Superfund Site** is located in Abbeville, Vermillion Parish, Louisiana. The site is an inactive waste facility that handled wastes primarily from oil and gas exploration. The company operated from approximately 1969 to 1984. Oilfield wastes were dumped into two pits creating approximately 22,000 yd^3 of sludge. Approximately 44,000 gallons of sludge and liquid were contained in five aboveground storage tanks. The principal contaminants in the site sludge and groundwater were benzene, toluene, mercury, lead, chromium, arsenic, and other organic compounds. The primary contaminants in site soils were arsenic and barium. Site soils and sludge were remediated with on-site biological treatment of contaminated soils/sludge and stabilization of contaminated on-site soils. The selected remedy for the groundwater operable unit was source control with pit dewatering and monitoring (USEPA 2004g).

The **Highlands Acid Pit Superfund Site** is located in Highlands, Harris County, Texas. Industrial wastes were deposited into on-site pits in the early 1950s. The principal contaminants at the site

included benzene, toluene, phenol and xylenes, sulfate, manganese, arsenic, cadmium, lead and beryllium. Approximately 8 feet of waste and heavily contaminated soil (22,000 yd^3) were excavated and disposed of off-site. The pit was backfilled, graded, seeded and fenced. The "No Action" remedy was chosen for groundwater because site contaminants were not detected in the middle or deeper aquifers. The remedy included the installation of monitoring wells and monitoring for 30 years. Subsequently, from 1997 to 1999, constituent concentrations in the middle and deeper aquifers exceeded drinking water maximum contaminant levels (MCLs) (USEPA 2004h).

The **Mallard Bay Landing Bulk Plant** is a Superfund Site located in Grand Cheniere, Cameron Parish, Louisiana. The site is an inactive crude oil refining and bulk storage facility on ten acres of land. Recreational fishing occurs 500 feet south of the facility and the Lacassine National Wildlife Refuge is located approximately 10 miles west of the facility. From 1980 to 1983, the facility refined mixed crude oil to produce naphtha, diesel fuel, and No. 6 fuel oil. In August 1985, the facility resumed crude oil refining until declaring bankruptcy in 1987. Tank wastes contained styrene, benzene, toluene, ethylbenzene, xylenes, 2-methylnaphthalene, naphthalene, arsenic, barium, chromium, copper, lead, manganese, mercury, nickel, vanadium and zinc. Wetland sediment samples contained elevated concentrations of arsenic, barium, copper, manganese, mercury, nickel, vanadium and zinc. Over 200,000 gallons of sludge were extracted/excavated from the site and treated by thermal destruction/off-site energy recovery. Approximately 1100 yd^3 of contaminated soil were excavated and disposed of in an off-site landfill. A remedy was not developed for groundwater since it met state and federal standards (USEPA 2004i).

The **MOTCO Superfund Site** is located at the intersection of Interstate 45 and State Highway 3 in LaMarque, Galveston County, Texas. The site is located within a 100-year floodplain and on a gulf coastal marsh at the edge of the Galveston Bay system. The site was developed in 1958 for waste recycling and operations continued until 1968 when Hurricane Carla ended the recycling operation. MOTCO Corporation acquired ownership in 1974 and established an operation to remove and market the styrene tars. The site was abandoned the same year. The MOTCO Superfund Site included seven pits that contained styrene tars, VOCs, heavy metals and bis(2-chloroethyl ether). Waste volumes at the site included fifteen million gallons of pit water, 14,000 tons of pit sludge and tars and seven million gallons of pit organic liquids, 60,000 tons of soil, and four million gallons of DNAPLs. The original source control remedy chosen by USEPA and the MOTCO Trust Group was on-site incineration of sludge/tars and soils. The source control remedy implemented at the site included off-site incineration of liquids, sludge and tar and on-site landfilling of soil. Slightly contaminated surface soils were excavated, consolidated and capped in an on-site landfill (USEPA 2004j). The groundwater remedy includes recovery and treatment of contaminated groundwater and recovery and incineration of DNAPLs (TCEQ 2004b).

The **Old Inger Oil Refinery Superfund Site** is located adjacent to the Mississippi River levee in Ascension Parish, Louisiana. The site began operations as an oil refinery in 1967 and began to reclaim refinery wastes in 1976 until closure in 1980. The major site contaminants are PAHs (up to 49 ppm

phenanthrene) in sediment and heavy metals (up to 130 ppm zinc) in sediment. The soils and sediment remedy comprised a land treatment bioremediation unit for approximately 58,000 tons of soils. Bioremediation started in December 1998 and the process (including grading, capping and seeding the unit) was completed by October 2001. Groundwater will be pumped and treated using carbon adsorption. Surface water will be treated with carbon adsorption and discharged off-site (USEPA 2004k).

PAB Oil and Chemical Service Superfund Site is located in Vermillion Parish, Louisiana. The site was operated as a disposal facility for oil field waste from 1979 to 1983. The site, approximately 17 acres, consisted of three disposal pits and four holding tanks. The pits cover about 2.6 acres, with about 20,000 yd^3 of soils and sludge, and six million gallons of surface water. Major contaminants in the pit sludge include arsenic, barium, chromium, lead, manganese, acetone, ethylbenzene, toluene, xylene and polyaromatic hydrocarbons. Approximately six million gallons were removed from the saltwater pond and treated in an electroprecipitation unit prior to discharge. The proposed remedy for the sludge and soils was bioremediation. Bioremediation was removed from the remedy after newer analytical methods with lower detection limits demonstrated that concentrations were below levels that were an environmental threat. Pit sludge and sediments from the pond bottom were stabilized and solidified in the pit areas and covered with a clay cap. Currently the site groundwater is periodically sampled and analyzed (USEPA 2004l).

The **Petro-Chemical Systems (Turtle Bayou) Superfund Site** is located on Frontier Park Road, south of Liberty, Liberty County, Texas. Site operations began prior to 1970 and continued into the late 1970s. Waste oils were dumped along Frontier Park Road and into unlined waste pits along the road. Approximately 5,900 yd^3 of waste containing naphthalene, chrysene, fluorene, and benzene were located in the road area, while 300,000 yd^3 of surface soils containing benzene, naphthalene and lead are located on the remainder of the site. Groundwater contains naphthalene, styrene, and benzene. Soil was excavated from and adjacent to Frontier Park Road followed by placement of the contaminated soil within a temporary on-site RCRA storage facility. The source control remedy includes multiple components to optimize the remedial operations efficiency: soil vapor extraction, bioventing, excavation and treatment and/or off-site disposal of site "hot spots". In-situ bioremediation of contaminated groundwater is the second component of the source remedy (USEPA 2004m).

The **Petro-Processors of Louisiana Superfund Site** consists of two locations, the Scenic Highway location and the Brooklawn location, near Scotlandville, East Baton Rouge Parish, Louisiana. Portions of Devil's Swamp and Bayou Baton Rouge are adjacent to the Brooklawn location. The Scenic Highway location originated as a borrow pit used for petrochemical waste disposal from 1961 to 1974. Once the Scenic Highway location was filled, the Brooklawn location opened about 1.5 miles away. Brooklawn operated from 1969 to 1980. The principal contaminants are chlorinated hydrocarbons (such as hexachlorobutadiene and hexachlorobenzene), PAHs, heavy metals and oils. As part of the remedy, Bayou Baton Rouge was rerouted away from the site and engineered clay caps were placed over the pits and ponds. Hydraulic containment systems consisting of recovery wells and sumps were

installed at both the Scenic and Brooklawn sites. A groundwater Liquid Treatment and Disposal System operating at Brooklawn includes the following components: phase separating water and organics, air stripping the contaminated water, incinerating fumes from the air strippers and organic liquids from the phase separators, polishing the treated water with carbon adsorption and discharging. Contaminated liquids from the Scenic site are treated at Brooklawn. A total of 3,034 feet of the Devil's Swamp Channel were remediated (USEPA 2004n).

The **Sheridan Disposal Services Superfund Site** is located about nine miles northwest of Hempstead, Waller County, Texas. Sheridan collected waste oils and solvents from 1963 to 1973 for disposal in an on-site surface impoundment, landfarm, and incinerator. Approximately 44,000 yd^3 of sludge and contaminated soils are found in the 15-acre lagoon. Sludge in the former waste lagoon contains up to 5% VOCs such as benzene, ethylbenzene, toluene, and trichloroethene, PCBs, and up to 30% heavy metals. The remedy selected for the waste ponds, tanks and soils is in-situ solidification/stabilization with a RCRA-compliant cap installed over the lagoon and dike area. The groundwater remedy utilizes natural attenuation to alternate concentration limits established as site groundwater protection limits (USEPA 2004o).

The **Sikes Disposal Pits Superfund Site** is located about 2 miles southwest of Crosby, Harris County, Texas. A variety of chemical wastes from the petrochemical industry was disposed of in on-site unlined sand pits from the early to late 1960's. Wastes contained organic chemicals and heavy metals such as arsenic, mercury, cadmium, chromium, and lead. Approximate waste volumes at the site were 350 million gallons of contaminated ground and surface water, 496,000 tons of organic sludge and contaminated soils, and 2000 drums of mixed waste. Wastes, sludge and groundwater were treated with incineration. An on-going groundwater monitoring program was implemented after the incineration was completed (USEPA 2004p).

4.2 Remedial Alternatives

Table 4 summarizes the remedial alternatives evaluated and chosen for the example sites for groundwater. Tables 5 and 6 summarize the remedial alternatives evaluated and chosen for the example sites for soils and sludge. Information about the remedial alternatives were obtained from Site Summaries, Records of Decisions (RODs), Explanation of Significant Differences (ESDs) and 5-Year Reviews publicly available on the USEPA Region 6 web page.

4.2.1 Groundwater

The groundwater remedial alternatives were classified into the following broad categories:

- bioremediation,
- underground injection well disposal,
- monitored natural attenuation (MNA),
- pump and treat, and

- vertical barrier wall.

Of these, containment response actions for groundwater are:

- pump and treat,
- vertical barrier walls (such as a permeable reactive barrier or slurry wall) and
- MNA.

The remaining technologies represent treatment response actions:

- bioremediation,
- deep well disposal,
- MNA, and
- pump and treat technologies (including carbon absorption, biological, air stripping, etc.).

Pumping with treatment and discharge was evaluated as a technology for ten sites, and was selected as the remedy at four sites. The technology was eliminated in the six other sites because active treatment was not warranted, was too costly compared to the chosen technology, and concern about on-site worker exposure or ability to meet discharge criteria.

Monitored natural attenuation (MNA) was evaluated as the groundwater remedy for nine sites and chosen as the remedy for eight. MNA was not chosen as the remedy for the MOTCO Superfund Site due to lack of protectiveness.

Vertical barrier walls were evaluated as a containment technology for five sites and selected as a remedy for two sites (Brio Refining and MOTCO Superfund Sites). The vertical barrier wall was eliminated as a technology for the other three sites because it was not deemed reliable for the site hydrologic and hydrogeologic conditions, difficulties in maintaining the wall in a flood-prone area, or exposure to on-site workers.

Deep well injection disposal was evaluated as a technology at three sites and was not chosen as the remedial alternative for any site. Deep well injection was eliminated as a feasible technology due to the transportation and disposal costs for using a commercial facility.

Bioremediation was evaluated at two sites and chosen as the remedy for one site. The technology was not chosen for the Bailey Waste Disposal site because active treatment of the groundwater was not warranted.

4.2.2 Soil/Sludge

The soil and sludge remedial alternatives were classified into five broad categories based on the primary treatment technology specified in the ROD:

- bioremediation,
- cap,
- incineration,
- landfill, and

- solidification/stabilization.

Containment response actions evaluated at the sites included:

- capping,
- on-site landfills, and
- vertical barriers.

Treatment response actions included:

- bioremediation,
- incineration, and
- solidification/stabilization.

Some of the remedial alternatives considered require combinations of remedial technologies. The remedial alternative evaluations for the on-site landfill included a final cap after waste placement. The incineration technology evaluations included treatment of the ash using solidification/stabilization and placement of the solidified/stabilized material in an on-site or off-site landfill. Landfills included on-site or off-site facilities. Solidification/stabilization evaluations included pozzolanic and encapsulation options.

Solidification/stabilization was evaluated as the primary remedial alternative at twelve sites and was chosen as the remedy at seven sites. The remedy was not chosen as the primary remedy at the other sites because solidification/stabilization did not adequately prevent the migration of organic contaminants nor was the technology viewed as providing long-term protection. Solidification/stabilization was removed from the ROD for the Bailey Waste Disposal site due to the inability of the contractor to meet the performance specifications and a more stringent cap design was implemented.

Incineration (off-site or on-site) was evaluated as the primary remedial alternative at twelve sites and was chosen as the on-site remedy at three sites (Brio, MOTCO, and Sikes). Off-site incineration was only chosen as the remedy for waste oils and non-aqueous phase liquids (NAPLs) such as at MOTCO. The technology was successfully implemented on-site at Sikes where the sludge was more tar-like due to low moisture content. The technology was removed as a remedy for sludge and soils at Brio and MOTCO due to concerns about volatiles emissions and the inability to efficiently process the sludge. The technology was not chosen as the primary remedy at the other sites because of cost concerns.

Bioremediation was evaluated as the primary remedial alternative at eleven sites and chosen as the primary remedy for soils or sludge at four sites. The reasons cited for not choosing the technology included: not appropriate for metals content at site; additional analytical data eliminated the need for remediation; or untreated contaminants would not migrate off-site.

Containment of contaminated soils or sludge in on-site landfills was evaluated as the remedy for seven sites. The technology was only chosen as the temporary primary remedy for the Petro-Chemical Systems (Turtle Bayou) Operable Unit 1. Approximately 5,900 yd^3 of soil contaminated with PAHs or VOC concentrations exceeding 100 mg/kg were excavated from Frontier Park Road and placed in

a temporary, aboveground landfill on-site. This action was taken to prevent direct contact of residents to highly contaminated soils, to minimize direct contact with moderately contaminated soils, and to consolidate waste materials on-site. As part of the ROD for the second operable unit, the on-site landfill will be dismantled and the soils in the landfill will be treated. On-site landfills without prior treatment of the waste were not chosen as permanent remedies for any sites.

Off-site landfills were evaluated as the remedy for seven sites and chosen as the final remedy for the Highlands Acid Pit and Bailey Waste Disposal. Waste materials at the Highlands Acid Pit were excavated to approximately eight feet and transported to a Class 1 hazardous waste disposal facility. The excavation was backfilled and a temporary perimeter fence was installed. Contaminated marsh sediments and waste (approximately 12,000 yd^3) from the Bailey Waste Disposal Site were excavated and transported to a Class 1 hazardous waste disposal facility.

Capping of contaminated soils and sludge was evaluated as the remedy for five sites and chosen as the final remedy for three sites. Slightly contaminated soils and sludge at the Old Inger Oil Refinery were capped, while more contaminated materials were bioremediated. Engineered clay caps were installed over the sources at the Brooklawn and Scenic areas of the Petro-Processors of Louisiana site. The engineered clay cap at the Petro-Processor site was accompanied by extensive remediation of the groundwater. Capping the site with a cover system consisting of clay, synthetic liner and a gas collection system was chosen as the final remedy for the Brio Refining site. The cap was accompanied by sub-grade vertical wall for groundwater control.

4.3 Remedy Effectiveness

In addition to evaluating the remedy chosen at a Superfund site, there is a need to evaluate the long-term the effectiveness of the remedy. The NCP provides that remedial actions which result in any hazardous substances, pollutants, or contaminants remaining at the site above levels that allow for unlimited use and unrestricted exposure be reviewed every five years to ensure continuing protection of human health and the environment. Five-year reviews are available for six of the sites discussed above:

- Dutchtown Treatment Plant Superfund Site,
- Gulf Coast Vacuum Services Superfund Site,
- Highlands Acid Pit Superfund Site,
- PAB Oil and Chemical Services Superfund Site,
- Petro-Chemical Systems (Turtle Bayou) Superfund Site, and
- Sikes Disposal Pit Superfund Site.

The selected remedy at the **Dutchtown Treatment Plant Superfund Site** included (1) MNA of groundwater, (2) maintaining the existing clay cap and fence, and (3) implementing institutional

controls. The first five-year review for this site determined that the remedy was currently protective of human health and the environment and that the objectives of the ROD were being met (USEPA 2002a).

The selected remedy for Operable Unit (OU) 2 at the **Gulf Coast Vacuum Services Superfund Site** (Tetra Tech 2003) included (1) pumping and treating accumulated rainwater; (2) excavating and consolidation of sludge and soil into the West Pit; (3) placing an impermeable synthetic membrane over the consolidated material; and (4) backfilling clean soil into the excavated pit. The selected remedy for OU-1 included (1) on-site biological treatment of sludge, soil and tank contents; (2) stabilization and on-site disposal of bioremediation residuals; (3) stabilization and on-site disposal of metals contaminated soils; (4) capping of disposal area with a 2-foot compacted clay cover; (5) groundwater monitoring; and (6) institutional controls. The second (most recent) five-year review determined that the remedy was performing as intended and was currently protective of human health and the environment. The review noted, however, that groundwater concentrations of arsenic, barium, cadmium, and chromium exceeded maximum contaminant levels and did not show decreasing trends.

The selected remedies for the **Highlands Acid Pit Superfund Site** (USEPA 2002b) included (1) excavation and off-site disposal of sludge and surface capping to control erosion and (2) monitoring of site groundwater. The second five-year review of the site determined that the remedy was currently protective of human health and the environment. The review discussed, however, that site-related contaminants were detected in the middle and lower aquifers.

The selected remedy implemented for the **PAB Oil and Chemical Services Superfund Site** (USEPA 2002c) had the following components: (1) surface water treatment, (2) solidification/stabilization of the soils and sludge and on-site disposal, (3) clay cover over disposal, and (4) groundwater monitoring. The first five-year review determined that the remedy was protective of human health and the environment. Operation and maintenance (O&M) costs were reduced after a modified O&M plan decreased the number of wells sampled.

The first five-year review of the **Petro-chemical Systems, Inc (Turtle Bayou) Superfund Site** (USEPA 2000a) described the remedies for OU-1 and OU-2. The ROD for OU-1 required excavation of soil and placement in a temporary, aboveground on-site landfill. Soil vapor extraction and in-situ bioremediation for groundwater formed the major components of the remedy for OU-2. The five-year review found that the remedies for both operable units were protective of human health and the environment.

The second five-year review of the **Sikes Disposal Pits Superfund Site** (CH2M Hill 2001) stated that the remedy at the site continued to be protective of human health and the environment. The remedy at the site include (1) excavation and incineration of contaminated soils and sludge, (2) flood protection and erosion control, (3) water treatment and discharge, and (4) natural attenuation of groundwater contamination. Groundwater concentrations of contaminants were found stable or decreasing with respect to concentrations in previous sampling events.

4.4 Conclusions

MNA was chosen as the groundwater remedy for five of the comparable sites and a groundwater pump and treat process was chosen as the remedy for four sites. Generally, monitored natural attenuation was chosen as the groundwater remedy in conjunction with an active soil/sludge remedy. The most frequently chosen remedies for the soil or sludge were bioremediation and solidification/stabilization.

The five-year reviews for six of the sites determined that the remedies were protective of human health and the environment. However, concerns about groundwater concentrations of contaminants were noted in two of the reviews (Gulf Coast Vacuum Services Superfund Site and Highlands Acid Pit Superfund Site).

Three sites, the Brio Refining Superfund Site, the French Limited Superfund Site, and the MOTCO Superfund Site, were selected for a detailed screening of their history, remedial alternative evaluations in the FS and the costs to implement the remedies. As discussed in detail in the next section, these sites appear to be the most similar to the Malone site relative to contaminants, settings, and matrices.

5.0 DETAILED EVALUATION OF COMPARABLE SITES

As discussed in the previous section, numerous remedies for groundwater and soil or sludge at comparable Superfund sites were evaluated. Three sites, deemed most representative of the conditions at the MSC Superfund Site, were chosen for a detailed comparison of the source areas, COCs, geology, and hydrogeology. The three sites, the Brio Refining Superfund Site, French Limited Superfund Site, and the MOTCO Superfund Site, have been extensively investigated and the source control remedial actions have been completed.

5.1 Regional Geology and Hydrogeology

This section discusses the regional geology and hydrogeology common to the MSC Superfund Site and the three comparable sites.

5.1.1 Regional Geology

Upper Tertiary to Holocene surface outcrops in southeast Texas generally parallel the coastline, with older formations found progressively inland. The MSC Superfund Site, Brio Refining Superfund Site, French Limited Superfund Site and the MOTCO Superfund Site are all located on outcrops of Pleistocene and Holocene age deposits in Harris and Galveston Counties, Texas. These Pleistocene and Holocene sediments consists primarily of fluvial-deltaic, coastal and shallow marine deposits including from oldest to youngest:

- Lissie Formation of Pleistocene age
- Beaumont Formation of Pleistocene age
- Deweyville Formation of late Pleistocene or Holocene age
- Alluvium of Holocene age.

Figure 5 shows the Pleistocene and Holocene surface geology for part of Harris and Galveston County and the locations of the MSC Superfund Site and comparable Superfund sites. The stratigraphic units depicted on the map are summarized below from Aronow and Barnes (1982) and Aronow (2004).

Lissie Formation (Undivided)

The Lissie Formation consists of fluvial sand, silt, clay and minor amounts of siliceous gravel that become more abundant to the northwest. These fluvial and deltaic sediments were deposited during several interglacial high sea level stages similar to that present today. The surface expression of the upper part of the formation is fairly flat and featureless except for numerous rounded shallow depressions and pimple mounds. The relict fluvial surface morphology has been obliterated by water erosion, wind deflation and deposition, and by burrowing organisms and vegetation roots. Calcium carbonate concretions and iron oxide and iron-manganese nodules are common in the zone of weathering. The upper part is locally calcareous. The lower part of the Lissie Formation tends to have

coarser gravels, more abundant iron oxide nodules, and tends to be non-calcareous. The surface expression of the lower part of the formation is very gently rolling with moderate drainage. The Lissie Formation is generally greater than 200 feet thick.

Beaumont Formation

The Beaumont Formation consists primarily of clay, silt, sand, and gravel deposited in fluvial, deltaic and near coastal environments. Concretions and massive accumulations of caliche and concretions of iron oxide and iron-manganese oxides are common in the zone of weathering. The surface expression of the Beaumont Formation is almost featureless with the exception of relict fluvial features, river channel meanders, and pimple mounds on meander ridges separated by areas of relatively low, smooth featureless backswamp deposits without pimple mounds. Mapped areas dominated by clay and mud are associated with interdistributary, abandoned channel-fill, and fluvial overbank environments. Mapped areas dominated by clayey sand and silt are associated with meanderbelt, levee, crevasse splay, and distributary sand channel environments. The Beaumont Formation is generally greater than 100 feet thick. Barrier island and beach deposits of the Beaumont Formation consist mostly of fine-grained sands and are characterized by numerous pimple mounds and poorly defined relict beach ridges. These deposits include many recent locally active sand dunes and are probably part of the Ingleside barrier island system. The thickness of the barrier island and beach deposits is less than 30 feet.

Deweyville Formation

The Deweyville Formation consists primarily of sand, silt and clay with some gravel deposited in point bar, natural levee, stream channel and backswamp environments at a level slightly above that of the present floodplain. Sands associated with the Deweyville Formation are typically coarser-grained than the sand associated with recent alluvium. The surface expression is characterized by relict meanders of much larger radii, arcuate point bar complexes, channels, and meander scars cut into adjacent uplands that are larger than those of younger, sub-adjacent Holocene alluvium, and pimple mounds. High-level deposits of the Deweyville Formation cut into the Beaumont Formation and high-level Deweyville deposits along the Trinity River are intermediate in position between the surface of the Beaumont and the level of most Deweyville deposits. The Deweyville deposits tend to be absent along the Brazos River. The thickness of the local Deweyville deposits is more than 50 feet.

Alluvium and Barrier Island Deposits

Recent alluvium includes clay, silt, sand and locally abundant organic matter deposited in point bar, natural levee, stream channel, backswamp, coastal marsh, mud flat and beach depositional environments. These sediments are typically found within river valleys and stream channels and along the coast, bay and estuarine areas. The barrier island deposits primarily consist of sand with subordinate amounts of silt and clay. The depositional environments for these sediments include beach ridges, spits, tidal channels, tidal deltas and sand dunes. The sands tend to be well-sorted, fine-grained,

with abundant shell, and shell fragments, and the sands tend to interfinger with clay and silt in the landward direction. Barrier island deposits are primarily found along the seaward side of the Bolivar Peninsula and Galveston Island.

Conclusions

For these four Superfund sites, MSC, MOTCO, BRIO, and French Limited, the regional geology is essentially the same.

5.1.2 Regional Hydrogeology

The two principal hydrogeologic units that supply fresh to slightly saline water to the Harris and Galveston County area include the Evangeline aquifer and the Chicot aquifer. The geologic formations that comprise these aquifers, from oldest to youngest include: the Goliad Formation of the Pliocene age; the Willis Sand, Lissie Formation, and Beaumont Formation of the Pleistocene age; and the alluvium of the Holocene age. Regionally, these stratigraphic units dip toward the Gulf of Mexico at an angle greater than the land surface and tend to thicken progressively deeper basinward (Baker 1986). Collectively, these sediments attain a thickness in excess of several thousand feet along the coastline and consist primarily of interbedded sands and clays with subordinate beds of silt and gravel. The lithologic similarity of the post-Miocene age sediments makes delineation of the stratigraphic and hydrologic sections difficult in the subsurface. The Evangeline and Chicot aquifers are underlain by the Burkeville confining layer that restricts vertical communication with the underlying Jasper aquifer. Figure 6 presents a stratigraphic and hydrogeologic cross-section for the Harris and Galveston County area.

The Evangeline aquifer in Texas coastal plain is typically wedge-shaped, ranging in thickness from about 1500 to 1600 feet thick below the French Limited and Brio Superfund Sites to about 2200 feet thick beneath the MOTCO and MSC Superfund Sites which are near the coastline (Figure 6). The Evangeline aquifer is composed of the Goliad Sand, but the lower boundary of the Evangeline aquifer crosses time lines and in some areas may include sections of sand in the Fleming Formation. Individual sand beds are characteristically tens of feet thick (Baker 1979). The base of the Evangeline aquifer coincides with the base of the Goliad Sand in the outcrop area, and the upper boundary follows closely the top of the Goliad Formation.

The Chicot aquifer extends from the surface sediments down to the top of the Evangeline aquifer along the Texas Gulf Coast (Figure 6). The Chicot aquifer is composed of the Lissie Formation and the Beaumont Formation of Pleistocene age and any overlying Holocene alluvium. Delineation of the Chicot in the subsurface is generally based upon a higher sand-clay ratio in the Chicot than in the underlying Evangeline. Differences in hydraulic conductivity and/or water levels have also been used to differentiate the two aquifers.

Conclusions

The four detailed comparison sites share very similar hydrogeology. Both the MOTCO and MSC Superfund Sites are within 1 to 2 miles of each other and apparently, both overlie the same paleochannel system at different locations and share similar shallow stratigraphy. French Limited is located in the San Jacinto River floodplain with meander channels and underlying depositional, transmissive sandy silt strata similar to the Brazos River paleochannel beneath the MOTCO and MSC sites. As with the MOTCO and MSC Superfund Sites and similar to the French Limited site in the San Jacinto flood plain, the Brio site is in former Brazos River deltaic deposits, overlying several transmissive sand strata.

5.2 Chemical Composition

Tables 1 through 3 summarize the chemical constituents reported for the Brio Refining, French Limited and MOTCO Superfund Sites. These data were reported in the RI and FS reports compiled in the 1980's. The reported constituents do not necessarily reflect every chemical detected at the site, but only those chemicals that the authors of the reports felt were significant and contributed to the site risk.

Estimated waste volumes for the three sites ranged from 59,100 yd^3 to 70,000 yd^3. In contrast, the estimated volume of waste materials in the Oil Pit and the Sludge Pit at the MSC Superfund Site is 337,000 yd^3. If the materials contained within the API separators and tanks require treatment, the total volume of waste materials could exceed 375,000 yd^3.

The source materials at the MOTCO Superfund Site were acidic with pH ranging from 1.5 to 5.5 units. The pH of the waste materials at the Brio Refining, French Limited and MSC Superfund Sites were neutral, ranging from 5 to 8.8.

1,2-Dichloroethane, 1,1,2-trichloroethane, vinyl chloride, and bis(2-chloroethyl) ether were the dominant compounds detected in the sludge at the Brio Refining Superfund Site. These compounds as well as benzene, styrene, naphthalene, and phenanthrene were the dominant compounds in the wastes at the MOTCO Superfund Site. The chemical profile of the French Limited wastes differed slightly with chloroform, 1,2-dichloroethane, trans-1,2-dichloroethene, and vinyl chloride the dominant compounds. The waste materials at the MSC Superfund Site are comprised of slightly higher molecular weight chlorinated VOCs such as 1,1,1-trichloroethane, tetrachloroethene, trichloroethene, and hexachlorobutadiene, as well as aromatic compounds such as 2-methylnapthalene, xylenes, toluene and ethylbenzene. PAHs are a common constituent in the waste materials from all four sites. The MSC Superfund Site has appreciable concentrations of chromium, copper and lead in the waste materials, while copper and lead dominated the metals profile at the MOTCO Superfund Site. Copper was the major metal constituent in wastes at the Brio Refining Superfund Site. Numerous metals were detected in the sludge at the French Limited Superfund Site. Due to Toxic Substance Control Act (TSCA) requirements, the presence of PCBs in the wastes at the French Limited and MOTCO

Superfund Site limited the remedial alternatives suitable for these sites. PCBs have not been detected in the waste materials at the MSC Superfund Site.

The major common groundwater constituents at the four Superfund sites are 1,2-dichloroethane and vinyl chloride. In addition, the groundwater at the MSC Superfund Site also contains acetone, benzene, phenol, and xylenes, while the groundwater at the Brio Refining Superfund Site contains 1,1-dichloroethane, and 1,1,2-trichloroethane and the groundwater at the MOTCO Superfund site contains bis(2-chloroethyl) ether, bis(2-chloroisopropyl)ether, naphthalene, 1,1,2-trichloroethane and benzene. In contrast to the three example sites, the MSC Superfund Site contains arsenic, manganese and other metals exceeding human health standards.

VOCs are common constituents in soils and sediments at all four Superfund sites, however the profiles differ slightly between the sites. The major VOCs in soils and sediments at the French Limited Superfund Site are aromatic compounds, including benzene, ethylbenzene, toluene as well as 1,2-dichloroethane. The major VOC constituents at the MOTCO and Brio Refining Superfund Site are 1,2-dichloroethane, ethylbenzene, and 1,1,2-trichloroethane. In addition, styrene was prevalent in the soils at the MOTCO site. The major VOC constituents in the limited soil data set at the MSC Superfund Site are trichloroethene, 1,1,1-trichloroethane, and toluene.

PAHs dominate the SVOC profiles at all four sites, with bis(2-chloroethyl)ether and bis(2-chloroisopropyl) ether as major contaminants at the MOTCO Superfund Site and PCBs as major contaminants at the French Limited Superfund Site.

Conclusions

The four sites share many of the same chemical constituents and in the same matrices. Each site has/had sludge present in impoundments or pits. The sludge consisted of spatially variable tars, emulsions and oils containing mixes of volatile and semivolatile chlorinated and non-chlorinated organic compounds. Metals were present at all sites. Many of the metals were common to all the sites because wastes at these sites were generated from similar processes and in some cases from the same process or facility historically.

5.3 Brio Refining Superfund Site

The Brio Refining Superfund Site is located at 2501 Dixie Farm Road in southern Harris County near Friendswood, Texas. Operations began at the site in 1957 and included by-product recycling, copper catalyst regeneration, petrochemical recovery, and jet fuel processing. Approximately 5,000 people lived within one mile of the site. Major features of the site included two impoundments in the wastewater treatment system and numerous earthen storage pits. The pit areas ranged from 2,600 ft^2 to 92,040 ft^2 with a maximum depth of 15.4 feet. Extensive investigations were conducted at the site in the 1980's under the auspices of the TCEQ and USEPA.

Contaminants were found in on-site pits and consisted of styrene tars, vinyl chloride, chlorinated

solvent residues, metal catalysts and fuel oil residues. The USEPA estimated approximately 62,000 yd^3 of soil and 40,000 yd^3 of sludge and liquids remained at the site prior to remedial action. Approximately 100,000 gallons of sludge and solids were removed from the tanks. Over 82,000 gallons of DNAPL have also been removed from the site and 25 million gallons of groundwater have been treated. On-site soil and groundwater are contaminated by 1,2-dichloroethene, 1,1,2-trichloroethane, vinyl chloride, fluorene, anthracene, phenanthrene, pyrene and other hydrocarbons, and copper (USEPA 2004c). The remedial alternatives at the site include installing a sub-grade vertical barrier wall enclosing the site, capping the site with a cover system, controlling groundwater within the containment system, and improving an adjacent drainage body (Mud Gully) (TCEQ 2004a).

5.3.1 Remedial Alternatives

Table 7 summarizes the affected media and remedial objectives for the site.

Six remedial alternatives were developed for the site and screened for technical feasibility and environmental effectiveness (IT 1988). Table 8 summarizes the feasibility and effectiveness of these remedial alternatives. Based on these screening criteria, the No Action/Monitoring and Off-site Disposal remedial alternatives were eliminated from consideration in the detailed screening because of unacceptable evaluations for feasibility or effectiveness in the initial screening.

The FS evaluated the remaining four remedial alternatives, Cap and Cover, Vault, Biological Treatment, and Incineration, for technical feasibility, public health and environmental assessment, cost, and regulatory compliance (IT 1988). Based on the discussion in the FS, Table 9 summarizes the advantages and disadvantages of each technology.

As part of the detailed evaluation of the alternatives, the present worth (in 1988 dollars) of each alternative was calculated. Table 10 summarizes the present worth in 1988 and 2004 dollars for each alternative (including implementation and operation and maintenance), as well as calculates a treatment cost in dollars per cubic yard (2004 dollars) for each alternative. These costs are based on the original estimates of the wastes that required treatment and costs presented in the ROD (USEPA 1988c). The 2004 costs were calculated from the Consumer Price Index (1913-2004) ratio between January 1988 and April 2004 (BLS 2004). Bids received for the incineration remedy revised the estimate to over $40 million. USEPA estimated that the 30-year present worth for implementing the remedy was $77.5 million. Costs for the containment remedy chosen in the ROD amendment were estimated as $42.7 million (USEPA 1997).

In March 1989, USEPA issued a ROD that selected the on-site incineration of pit residuals. Additional components of the remedy included removal of surface contamination, channel improvements to Mud Gully, demobilization of process equipment and removal of debris, removal of DNAPL, and pumping and treating groundwater in the numerous sand channel zone (USEPA 1997). Implementation of the remedy was governed by a consent decree between USEPA and the BSTF signed in April 1991.

5.3.2 Remedy Implementation

A rotary kiln incinerator and support equipment were mobilized to the site after approval of the remedial design in July 1993. Temporary enclosures were erected over the pits to contain emissions during excavation. Emission problems during excavation led to a "stop work" order and in May 1994 the BSTF submitted a force majeure claim that short-term air standards set by USEPA for implementation of the remedial action would result in delay of compliance with the milestone schedule in the Consent Decree.

In response to requests from the public, the USEPA Ombudsman and the Superfund Revitalization Office issued a report in April 1994 stating that several issues needed resolution before continuing implementation of the incineration remedy. In August 1994, USEPA notified the BSTF that the incineration remedy would be re-evaluated. The incinerator and support equipment were demobilized from the site by December 1994.

Based on the result of a focussed FS, and discussions between USEPA, the Community Action Group, and the BSTF, a containment alternative was chosen as the remedy in the 1997 ROD Amendment (USEPA 1997). This remedy include the following components:

- Installing a sub-grade vertical barrier wall enclosing the site;
- Capping the site with a cover system consisting of compacted clay, liner, and gas collection system;
- Constructing a groundwater flow control system to manage migration of contaminants within the containment system; and
- Improvements to Mud Gully to ensure flow capabilities within the drainage system.

The DNAPL recovery portion of the original ROD was not affected by the amendment. Construction of the containment remedy at the Brio Refining Superfund Site was declared complete on November 13, 2003 (USEPA 2003b).

5.4 French Limited Superfund Site

The French Limited Superfund Site is located two miles southwest of Crosby, Texas in northeast Harris County. The site was used for sand mining operations between 1950 and 1965. From 1965 to 1972, the site was permitted by TCEQ for petrochemical waste disposal. Extensive investigations were conducted at the site in the 1980's under the auspices of the TCEQ and the FLTG. Groundwater contained VOCs and phenols at 10 ppm. Sludge contained VOCs (6%), phenols (1%), heavy metals (2%), and PCBs (310 ppm). The waste volume consisted of 8,000 yd^3 of PCB-containing sludge, 68,000 yd^3 of non-PCB sludge, 25,000,000 gallons of groundwater, and 70,000 yd^3 of soil. Contaminated soils were treated on-site using in-situ bioremediation. Groundwater was extracted and treated with biological remediation and carbon absorption prior to discharge to the San Jacinto River (USEPA 2004f).

5.4.1 Remedial Alternatives

Table 11 summarizes the media objectives and response actions for the site (TWC 1987).

Remedial alternatives applicable to the French Limited Superfund Site were developed and scored using procedures described in the NCP (TWC 1987). Table 12 summarizes the remedial alternatives. During the initial scoring, alternatives were evaluated and rated for effectiveness, engineering feasibility, and confidence. Alternative 9 (on-site incineration of sludge and contaminated soils above background levels) was screened from additional evaluation because the cost was significantly greater than the other alternatives. The alternatives involving biological treatment of sludge (alternatives 4, 6, 7, and 8) were not retained for additional evaluation because very little data existed at the time as to the effectiveness of the remedial alternative with heavily contaminated sludge. In addition, remedial alternative 2 (on-site incineration of sludge and thermal stripping of contaminated soils) was eliminated because of lack of data on the application of thermal stripping technology to large quantity of contaminated soils within a reasonable time frame. Remedial alternative 5 (on-site incineration of sludge and water leaching of contaminated soils) was eliminated due to the uncertainty of the water leaching process. Upon completion of the initial evaluation, remedial alternatives 1 (on-site incineration of sludge and contaminated soils), 3 (on-site incineration of sludge and chemical fixation of contaminated soils), and 10 (isolate sludge and contaminated soils within a slurry wall and cap), along with the no-action alternative 11 remained for detailed evaluation.

Advantages and disadvantages of each of the final remedial alternatives were considered in the detailed evaluation (Table 13). It was estimated that remedial alternative 1 (on-site incineration of sludge and contaminated soils) would have required the incineration of approximately 149,600 in-place yd^3 of sludge and soils and the chemical fixation of approximately 110,200 yd^3 of ash. Remedial alternative 3 (on-site incineration of sludge and chemical fixation of contaminated soils) would have required the incineration of 72,000 in-place yd^3 of sludge and PCB contaminated soils. The alternative would also have required the stabilization of approximately 25,700 yd^3 of ash and 77,600 in-place yd^3 of soil. Remedial alternative 10 (isolate sludge and contaminated soils within a slurry wall and cap) required the isolation of approximately 149,600 in-place yd^3 of sludge and contaminated soils within a non-RCRA, TSCA cell in the main waste pit. Remedial alternative 11 was the required no-action alternative.

As part of the detailed evaluation of the alternatives, the present worth (in 1987 dollars) of each alternative was calculated. Table 14 summarizes the present worth in 1987 and 2004 dollars for each alternative (including implementation and operation and maintenance), as well as calculates a treatment cost in dollars per cubic yard (2004 dollars) for each alternative. The 2004 costs are based on the original estimates of the wastes that required treatment and costs as presented in the FS (TWC 1987). The 2004 costs were calculated from the Consumer Price Index (1913-2004) ratio between January 1987 and April 2004 (BLS 2004).

After the issuance of the FS, the FLTG implemented an on-site pilot study to evaluate the remedial

effectiveness of in-situ biological sludge treatment. The results of the pilot study, submitted to the USEPA in October 1987, indicated that the contaminants of concern, except for PCBs and arsenic, were reduced to concentrations below the cleanup criteria established for the French Limited Superfund Site. Air emissions during the pilot treatment did not present a significant health threat. In the later in situ demonstration using downdraft aerators, the EPA felt air emissions were excessive and this drove the RD to the use of pure oxygen to support bioremediation. Groundwater monitoring results indicated some degradation of the water quality in the Upper Aquifer during the pilot study. Sludge on the bottom of the lagoon formed a seal that was hypothesized to retard leachate generation. Aeration broke the seal allowing leachate to contaminate the Upper Aquifer. The time frame for implementation of the remedy was estimated as four years with an estimated present worth cost of $47 million (USEPA 1988c).

5.4.2 Remedy Implementation

USEPA initially proposed incineration as the remedial technology for the sludge and soils. After review of the FLTG study, USEPA selected in-situ bioremediation as the final remedy for the French Limited Superfund Site (USEPA 1988c) with incineration, as a backup if the bioremediation failed. The components of the remedy included:

1. In-situ biodegradation of sludge and contaminated soil.
2. Recovery and treatment of contaminated groundwater until modeling showed a reduction in the concentration of VOCs such that natural attenuation can achieve the 10^{-6} human health criteria in ten years or less.
3. Treat as necessary to meet surface water discharge criteria and discharge surface waters from the lagoon to the San Jacinto River.
4. Stabilize the treated residue and dispose on site.
5. Backfill the lagoon to grade and grade the surface to promote drainage.
6. Monitor the Upper and Lower Aquifers for a period of ten years.

The slurry-phase bioremediation process was operated from January 1992 through November 1993 and achieved the specified cleanup goals for the five target contaminants, arsenic, benzo(a)pyrene, benzene, total PCBs, and vinyl chloride within eleven months of treatment per cell. Costs for the slurry-phase bioremediation system, including technology development, project management, USEPA oversight, and backfill of the lagoon were approximately $49 million with approximately $27 million directly associated with the treatment (USEPA 1995).

Several innovative technologies used in the process contributed to the success of the remediation (USEPA 1995). Controlled shearing was an essential factor in controlling growth of biomass. Sludge was sheared and introduced into the mixed liquor using centrifugal pumps while subsoil was sheared and introduced into the mixed liquor using cutter head dredges. Dissolved oxygen levels and pH were

also used to control biomass growth. Treating the sludge and soil separately kept the sludge from coating the soil particles, maximized the surface area for treatment, and reduced particle settling. The pure oxygen aeration system lowered air emission during the remediation. Higher transfer efficiency and high-purity oxygen reduced offgassing and air emissions. Simple batch systems were used to control pH and nutrient chemistry. Urea and liquid ammonium phosphate were added to obtain the highest percent nitrogen and phosphorus, respectively.

In addition to source remediation, aquifer remediation components included operation and maintenance of an aboveground, biological unit for groundwater treatment from 1991 to 1995. In 1998, FLTG enhanced the aquifer and groundwater remediation with injections of oxygen and nutrients to stimulate subsurface in-situ biological treatment.

The second five-year review of the French Limited Superfund Site was completed in March 2000 (USEPA 2002d). The source control was still protective of human health and the environment, however portions of the groundwater units were not expected to meet compliance criteria at the end of the compliance period in 2005. These portions of the groundwater units were not considered an immediate threat to human health and the environment. Mobile DNAPL beneath the lagoon and immobile DNAPL between the site and an adjacent public road were successfully contained and significant reductions in groundwater contamination were observed.

5.5 MOTCO

The MOTCO Superfund Site is located at the intersection of Interstate 45 and State Highway 3 in LaMarque, Galveston County, Texas. The site is located approximately 1.5 miles west of the MSC Superfund Site. The site is located within a 100-year floodplain and on a gulf coastal marsh at the edge of the Galveston Bay system. Approximately 3000 peopled lived within a 1-mile radius of the site in 1985. The site was developed in 1958 for waste recycling and operations continued until 1968 when Hurricane Carla ended the recycling operation. MOTCO Corporation acquired ownership in 1974 and established an operation to remove and market the styrene tars. The site was abandoned the same year. Several investigations were conducted at the site in the 1980's. EPA sponsored studies in 1981 and 1982 (B&V 1981, B&V 1982) confirmed the presence of affected shallow groundwater but did not vertically or horizontally delineate the extent of the affected groundwater or soils. The MOTCO RI/FS was divided into two components: source control (WCC 1984) and management of migration (MOM) (WCC 1988).

The MOTCO Superfund Site included seven pits that contained styrene tars, VOCs, heavy metals and bis(2-chloroethyl ether). Waste volumes at the site included 15 million gallons of pit water, 14,000 tons of pit sludge and tars and 7 million gallons of pit organic liquids, 60,000 tons of soil, and 4 million gallons of DNAPLs. The source control remedy at the site included off-site incineration of liquids, sludge and tar and on-site landfilling of soil. Slightly contaminated surface soils were excavated, consolidated and capped in an on-site landfill (USEPA 2004j). The groundwater remedy includes

recovery and treatment of contaminated groundwater and recovery and incineration of DNAPLs (TCEQ 2004b).

5.5.1 Remedial Alternatives

The MOTCO Superfund Site was separated into two operable units: source control (OU 01) and management of migration (OU 02). The source control operable unit included waste pits containing contaminated water and organic waste liquids and one-foot of soil beneath the sludge/soil interface. The management of migration operable unit included surface soils, surface sediments, surface water, subsurface soils, shallow groundwater and deep groundwater. Table 15 summarizes the media objectives for both operable units at the MOTCO Superfund Site (USEPA 1985, USEPA 1989).

Remedial alternatives applicable to source control operable unit at the MOTCO Superfund Site were developed and screened using procedures described in the NCP (USEPA 1985). Table 16 summarizes the remedial alternatives. Waste characteristics limited the types technologies that could be considered. Since the organic liquids were ignitable and contaminated with PCBs, TSCA would not allow the landfill of PCB contaminated ignitable liquids. The liquids could not be solidified so a landfill disposal option for the liquids was eliminated. During the initial screening, alternatives were evaluated for costs, effectiveness, and engineering feasibility. The No Action alternative was rejected because the alternative would allow continued releases of hazardous contaminants to the air, surface water, and groundwater. Alternative 4 (incineration at TSCA facilities) and alternative 6 (off-site incineration of sludge and tars) were rejected because of the high cost for off-site incineration. Alternative 5 (off-site incineration/on-site RCRA landfill), alternative 6 (on-site landfill of soils), and alternative 8 (on-site landfill of contaminated soils and sludge/tars) were rejected because wastes would remain on-site, higher costs than alternate methods of disposal without compensating advantages, and long-term operation, maintenance, and monitoring required. Alternative 9 (on-site liquid incineration), was rejected because other hazardous media (sludge and tars) would still have to be transported off-site. Upon completion of the initial evaluation, remedial alternatives 2 (off-site incineration/off-site landfill), 3 (off-site incineration/off-site RCRA/TSCA landfill), 10 (on-site incineration/off-site landfill), and 11 (on-site incineration/on-site RCRA/TSCA landfill) remained for detailed evaluation.

Advantages and disadvantages of each of the final remedial alternatives were considered in the detailed evaluation. Table 17 summarizes advantages and disadvantages of the four alternatives retained for detailed evaluation (USEPA 1985). After weighing the advantages and disadvantages of each alternative and a review of the detailed costs, USEPA chose Alternative 3 (off-site incineration/off-site RCRA/TSCA landfill) as the most cost-effective source control remedy. However, due to the uncertainty in the costs and capacity of TSCA-permitted incinerators, USEPA also decided to pursue alternative 10 (on-site incineration/off-site landfill) in the design phase. USEPA scheduled the construction phase of the remedy to begin in September 1986 and estimated a three-year completion schedule for Alternative 3 and a four-year completion schedule for Alternative 10.

Table 16 summarizes the remedial alternatives evaluated for the management of migration (OU 02) operable unit at the MOTCO Superfund Site (USEPA 1989). USEPA selected Alternative 4 (groundwater treatment and soil consolidation with capping) as the remedy for OU 02. The remedial design approved by USEPA for the management of migration operable unit included a cutoff slurry wall to enhance groundwater recovery and to control groundwater flow (USEPA 2004).

As part of the detailed evaluation of the alternatives, the present worth (in 1984 dollars) of each alternative was calculated. Table 18 summarizes the present worth in 1984 and 2004 dollars for each alternative (including implementation and operation and maintenance) for the source control operable unit, as well as calculates a treatment cost in dollars per cubic yard (2004 dollars) for each alternative. Table 19 summarizes the present worth (in 1989 dollars and 2004 dollars) for each management of migration remedial alternative. The costs in both these tables are based on the original estimates of the wastes that required treatment and cost estimates provided in the RODs (USEPA 1985; USEPA 1989). The 2004 costs were calculated from the Consumer Price Index (1913-2004) ratio between January 1987 and April 2004 (BLS 2004).

5.5.2 Remedy Implementation

The Consent Decree signed between the MOTCO Trust Group and USEPA required on-site incineration (USEPA XXXX). Two incinerators were selected for the site. One incinerator, consisted of a rotary kiln, a secondary combustion chamber, and a gas cleaning system, processed solids, sludge, tars, aqueous wastes, and organic liquids. The second incinerator, consisting of a combustion chamber and a gas cleaning system, processed aqueous wastes and organic liquids only. The incinerators operated from May 1990 to December 1991 and processed approximately 10,500 tons of aqueous wastes, 7,600 tons of organic liquids, 280 tons of sludge and tars, and 4,700 tons of soil, or approximately 21% of the estimated waste materials. Incineration ended in December 1991 when the contractor filed a lawsuit for breach of contract alleging that the chemical composition, quantities and mixtures of waste at the site were not as represented in the contract documents. The heat content of the waste exceeded the estimate by 40% and the viscosity substantially exceeded the estimate. The majority of waste was treated in the smaller rotary kiln incinerator instead of the combustion chambers, therefore there was insufficient capacity to treat solid sludge and soils and excess capacity to treat pumpable sludge. A number of technical difficulties were also encountered during operation of the incinerators: slag buildup, particulate carryover from the air pollution control device, dust blocking the flame detector in the kiln, overheating of the electrical switchgear, and low utility fuel gas pressure. In addition, a worker at the site was killed when removing timbers used to block open slide valves. USEPA estimated the actual cost to incinerate approximately 23,000 tons of waste was $3,300 per ton.

In 1993, USEPA issued an ESD that specified off-site incineration of the remaining sludge, tars and organic liquids. The remaining contaminated soil was included in the soil consolidation and capping remediation for the management of migration operable unit (USEPA 2004). USEPA signed the Preliminary Close Out Report for the MOTCO site on September 30, 1997, which documents

construction completion for the Source Control remedial action and the groundwater pump and treatment system for Management of Migration.

The five-year review for the MOTCO Superfund was completed in September 2002 (CH2M Hill 2002). The review indicated that the remedial actions were implemented as planned. The wastes in the original on-site pits were excavated, the wastes were stabilized, and disposed of in the excavated pits. A cap was placed over the stabilized wastes. A 55-foot deep slurry wall was placed around the perimeter of the site to prevent migration of affected groundwater and a groundwater extraction system was installed to maintain inward and upward gradients across the wall. Long-term response activities include the pumping of the affected groundwater and DNAPL from the Transmissive Zone within the slurry wall, pumping groundwater in the Upper Chicot beneath the site, on-site treatment and discharge of groundwater, off-site incineration of DNAPL, groundwater monitoring, and maintenance of the cap, slurry wall, and groundwater treatment plant. It was determined that the remedies were protective of human health and the environment for the short-term, provided action items were addressed. These action items included continued operation and maintenance of the long-term response activities and review of the bis(2-chloroethyl)ether exceedances of the compliance monitoring standard in the Upper Chicot-1 wells and outside the slurry wall.

5.6 Conclusions

The MSC Superfund Site, Brio Refining Superfund Site, French Limited Superfund Site and the MOTCO Superfund Site are all located on outcrops of Pleistocene and Holocene age deposits in Harris and Galveston Counties, Texas. These Pleistocene and Holocene sediments consist primarily of sand, silt, clay and lesser amounts of gravel deposited in fluvial-deltaic and shallow coastal environments.

Typically, the uppermost water-bearing transmissive zones within the upper 100 feet are related fluvial and deltaic channel and deltaic bar finger sands that may or may not be laterally extensive beneath the sites. More importantly, these upper transmissive zones are not significant as regional water supply sources. On a larger, macro-scale, the coarser-grained fluvial-deltaic deposits are generally contained both laterally and vertically by fine-grained, low permeability sediments that tend to prevent vertical communication with deeper aquifers below 100 feet.

The MSC Superfund Site is most directly comparable to the French Limited Superfund Site regarding the geology/hydrogeology and the primary waste source areas. At both sites, the primary source areas were former sand pits excavated into fluvial sand channels that were subsequently utilized for waste disposal. The local hydrology for these sites are influenced by groundwater movement downgradient along courses of the former channel, recharge effects by adjacent ditches, pits and ponds, and the mounding effect due to the waste impoundments.

The most significant difference between the MSC Superfund Site and the Brio Refining Superfund Site, French Limited Superfund Site and the MOTCO Superfund Site is the estimated volume of source material that may require treatment. The MSC Superfund Site has approximately five times as much

estimated volume of source material as the other three sites. All four sites have similar concentrations of VOCs and SVOCs in the waste materials, except that the concentration of bis(2-chloroethyl)ether is lower at the MSC Superfund Site than the MOTCO or Brio Refining Superfund Sites, The wastes at the MSC Superfund Site do not appear to contain PCBs. The waste materials at the MSC Superfund Site appear to have higher concentrations of arsenic, copper, chromium, lead and zinc. The groundwater contaminants and concentrations at the MSC Superfund Site most closely resemble those of the Brio Refining Superfund Site except that the concentrations of vinyl chloride and arsenic are higher at the MSC Superfund Site. All four sites contain similar concentrations of PAHs in soils and sediments, but the soil concentrations of VOCs at the MSC Superfund Site appear to be lower for all compounds except 1,1,1-trichloroethane and trichloroethene.

At all of the three comparison sites, incineration was a selected remedy for that site. In the two instances, where incineration was attempted (Brio and MOTCO), it was not effective as planned due to inability to control emissions and inability to efficiently treat the materials on site with the equipment, respectively. In each instance, the ROD and remedy were modified to combinations of containment and treatment remedies. At French Ltd., incineration was not tried at the site but was selected as the "fallback" should the selected, then novel, bioremediation remedy fail. The projected costs of incineration at French Ltd. were very high relative to the costs of the implemented remedy.

The five-year reviews for the French Limited and MOTCO Superfund sites showed their remedies were protective of human health and the environment, but concerns about concentrations of contaminants in groundwater were noted. Portions of the groundwater units at the French Limited Superfund Site were not expected to meet compliance criteria at the end of the compliance period in 2005. The bis(2-chloroethyl)ether exceedances of the compliance monitoring standard in the Upper Chicot-1 wells and outside the slurry wall at the MOTCO Superfund Site were also of concern. Both sites employed groundwater remedies that involved pumping and treating to remediate.

6.0 REMEDIAL ALTERNATIVES

As part of the development of the presumptive remedy for the MSC Superfund Site, remedies evaluated and implemented at other Superfund sites are discussed. This section presents a brief description of the various remedial technologies that have been evaluated at sites with a comparable history and setting to the MSC Superfund Site.

6.1 Groundwater

Groundwater remedies most frequently evaluated for comparable Superfund sites include monitored natural attenuation, barrier walls, pump and treat, and underground injection well disposal.

6.1.1 Monitored Natural Attenuation

Natural attenuation is a treatment technology that relies on physical, chemical or biological processes to achieve site-specific remedial objectives. These natural processes; biodegradation, sorption, dispersion and dilution, volatilization, and chemical reaction; under favorable conditions, can reduce the mass, toxicity, mobility, volume, or concentration of contaminants in the groundwater. Since natural attenuation relies on in-situ physical, chemical or biological processes, little or no residuals remain after the natural attenuation process is complete. The term "monitored natural attenuation (MNA)" is used to emphasize that long-term monitoring is an important component of a remedy where natural processes are to be relied upon to achieve cleanup objectives (USEPA 1999).

MNA was chosen as the groundwater remedy for eight (Bailey Waste Disposal, Dutchtown Treatment Plan, Gulf Coast Vacuum Services, Highlands Acid Pit, PAB Oil and Chemical, Petro-Processors of Louisiana, Sheridan Waste Disposal Systems, and Sikes Disposal Pits) of the sixteen comparable sites. Currently, the French Limited Superfund Site is undergoing MNA. Generally, monitored natural attenuation was chosen as the groundwater remedy in conjunction with an active soil/sludge remedy.

Potential advantages of MNA (USEPA 1999) include:

1. ability to implement other remedial alternatives, such as source control, concurrently with the MNA,
2. generation of a lesser volume of remediation wastes,
3. in-situ destruction of contaminants,
4. reduced risk of human exposure to contaminants, contaminated media, and other hazards,
5. reduced disturbances to ecological receptors, and
6. potentially lower overall remediation costs.

Potential disadvantages of MNA (USEPA 1999) include:

1. source control and long-term monitoring are coupled with the use of MNA in the Superfund process,
2. development of a contingency remedy if MNA fails to achieve the remedial action objectives or if drinking water sources are threatened,
3. longer time-frame to achieve remedial action objectives,
4. site characterization is more complex and costly,
5. toxicity and/or mobility of transformation products may exceed the parent compound (e.g., the transformation of trichloroethene and tetrachloroethene into vinyl chloride),
6. long-term performance monitoring will be more extensive, and
7. potential exists for continued contaminant migration, and/or cross-media transfer of contaminants, especially for those compounds that migrate rapidly or do not degrade readily.

The cost of a MNA program with long-term monitoring system is relatively inexpensive compared to other remediation technologies. Capital costs for implementing a MNA program are minimal since a treatment system is not designed and installed. Annual O&M costs for the MNA portion of the remedy at the French Limited Superfund Site range from $108,000 to $430,000 (USEPA 2002d). The $430,000 included the addition of supplemental oxygen to enhance natural attenuation.

6.1.2 Slurry Wall

A slurry wall is a containment technology that utilizes a subsurface barrier constructed to impede or redirect the flow of groundwater. Slurry walls have been used for over 50 years in the construction industry and for pollution control since 1970 (Pearlman 1999). Subsurface barrier walls are used to reduce mobility by isolating the contaminated soil, waste or groundwater within an enclosing barrier formed by a vertical trench excavated vertically into an underlying low permeability clay or shale and filled with a slurry of a clay such as bentonite, a mix of the clay and soil, or other materials as appropriate. This remediation technology can be used to contain organic contaminants, including light non-aqueous phase liquids (LNAPLs) and DNAPLs, PCBs, nonhalogenated VOCs and SVOCs, and inorganic contaminants. Slurry walls installed at many contaminated sites have successfully contained contamination within the site boundaries (NFESC 2004). Slurry walls have generally replaced the use of traditional cutoff barriers such as the steel sheet pile wall used at the French Limited Superfund Site and grout curtain walls (USACE 1996). Slurry walls may be used with pump and treat systems to manage any infiltrating water within the confined area and to prevent vertical migration down through a lower confining layer (e.g. clay).

Several pre-design issues should be resolved during the RI/FS. These include the initial compatibility testing of the contaminated groundwater with the soil-bentonite mixture. This test will determine the optimum soil-bentonite mixture to meet the permeability specifications and the long-term stability of

the slurry wall material in contact with the anticipated or known groundwater contaminants.

Materials used in the construction of slurry walls include soil-bentonite, cement-bentonite, plastic concrete, and cement. The most widely used construction material for environmental remediation projects is the soil-bentonite mixture. The soil/bentonite/water mixture is engineered to create a low-permeability cutoff wall (1×10^{-7} cm/sec to 1×10^{-8} cm/sec). Organic and inorganic contaminants can have a negative impact on bentonite, therefore additives, including fly ash can be mixed in to maintain the integrity of the slurry wall (Pearlman 1999). The installation of a slurry wall can take between one to two months to complete while continued monitoring to assess the performance of the slurry wall could take up to 20 years or longer.

Vertical barrier wall technology (including a slurry wall) has been implemented at the French Limited (sheet pile wall), MOTCO and Brio Refining Superfund Sites.

Advantages of slurry walls (Pearlman 1999) as a component of a remedy include:

1. Construction techniques are well understood.
2. Walls can be installed to depths of 200 feet.
3. The walls can be used with other remedy components.

The use of slurry walls in a remedy has some disadvantages:

1. Contaminants remain on-site. Mobility is reduced but toxicity or volume is not reduced.
2. The wall may degrade over time due to contact with the contaminants in the soil or sludge.
3. Extensive geological and stratigraphic studies are needed to ensure correct placement of the wall.
4. The installation of the slurry wall involves excavation and requires substantial handling of the contaminated soil or sludge by personnel, which can lead to exposure to the contaminants.
5. It may be difficult to remove the wall if a decision is made to switch to a different treatment technology because the remedial objectives are not being met.

A variation of the slurry wall incorporates a geomembrane liner into the trench of the slurry wall. Geomembranes are particularly useful above the water table where the soil-bentonite walls are susceptible to drying and cracking. The long-term durability of the geomembrane is not known because of relatively recent use in this application (Pearlman 1999).

The historical cost range for the installation of a wall system depends on the technology used for the wall:

- $25 to $80 per square foot of barrier – steel sheet pile with grouted joints (Depth 0 – 60’)
- $2 to $10 per square foot of barrier – soil bentonite slurry wall (Depth 0 – 80’)
- $6 to $15 per square foot of barrier – soil bentonite slurry wall (Depth 80 – 150’)

- $40 to $200 per square foot of barrier – grout wall (Depth 0 – 400')
- $8 to $25 per square foot of barrier – geomembrane (Depth 0 – 80')

These costs include barrier trench excavation (if applicable), barrier installation, sampling well installation, sampling and analysis for process control, and site supervision, quality assurance and health and safety support. Indirect costs, such as project management, site characterization, treatability, testing, design and engineering, vendor selection, permit preparation and fees and contingencies are not included (NFESC 2004).

O&M costs are relatively minimal compared to other remediation technologies (NFESC 2004). Costs include sampling and analysis for process control and routine monitoring of the wall integrity. The wall integrity should be routinely monitored as part of the O&M process. Several techniques are available, including gas tracers, electrical resistance tomography, ground-penetrating radar, and seismic/acoustic methods (Pearlman 1999).

6.1.3 Pump and Treat

A pump and treat system is a treatment technology that reduces the volume and toxicity of contaminants in the groundwater and secondarily on saturated soils. Contaminated groundwater is extracted with recovery wells or trenches and treated above ground. A pump and treat system includes components for extraction, aboveground treatment of the contaminated groundwater, disposal of the treated water, groundwater monitoring in the subsurface, and process monitoring in the treatment plant. Treatment technologies include air stripping, granular activated carbon, oxidation, biological reactors, chemical precipitation, or phase separation.

Pump and treat systems are used to treat dissolved contaminants, including VOCs, SVOCs, fuels, and dissolved metals. If the groundwater contains LNAPLs or DNAPLs additional equipment for phase separation prior to treatment must be installed. The highest removal efficiency observed in pump and treat systems is about 50% to 80%. Over long periods, pump and treat systems treat contaminants sorbed to saturated soils if the contaminants have some solubility. The efficiency of treatment of contaminants sorbed on soils is a function of the target cleanup concentrations, the relative solubility (equilibrium) of the contaminant in water, and the length of time available to clean up the site. Economically, pump and treat systems typically increase over time relative to the mass of contaminants removed per unit of time; that is, lower concentrations are recovered over time. At the end of the process when a portion of the contaminant mass has been removed, the pump and treat system operates in the containment mode. Pump and treat systems often are "completed" by periods of MNA, after active groundwater recovery is stopped.

A groundwater pump and treat process was chosen as the remedy for four sites (French Limited, MOTCO, Old Inger Oil Refinery, and Petro-Processors of Louisiana). Generally, monitored natural attenuation was chosen as the groundwater remedy in conjunction with an active soil/sludge remedy.

The advantages of pump and treat systems are:

1. Both treatment (decreases concentrations) and containment (reduces mobility);
2. Widely accepted and applicable to a wide range of contaminants;
3. Economical to install; and
4. Optimization of system performance over time can reduce O&M costs.

The disadvantages of a pump and treat system are:

1. The length of time to stop active treatment and implement MNA or other passive treatment technologies;
2. The contaminated site is also seldom restored to health-based standards, especially if NAPLs are present; and
3. Long-term monitoring costs.

The Department of Navy estimated that 69% of their sites would take greater than 10 years to achieve the remedial objectives using pump and treat (NFESC 2003). NAPLs sorbed to the soil can desorb back into the aquifer and contaminate the groundwater when pumping is complete; a process termed "rebound".

The capital cost for a pump and treat system can range from $24 to $440 per 1000 gallons of water treated per year for capital costs. Costs are influenced by the properties of the contaminants, hydrogeologic setting, extent of contamination, remedial goals, and system design and operation (USEPA 2001a). The Department of the Navy documented median and average capital costs of $3.4 million and $2.4 million, respectively for their sites (NFESC 2003).

O&M costs vary between $5 to $42 per 1000 gallons of water treated per year (USEPA 2001a). For example, O&M costs at the MOTCO Superfund site were approximately $675,000 in 2000 and $745,000 in 2001. This translates to approximately $91 per 1000 gallons of water treated (CH2M Hill 2002). The Department of Navy determined than the median and average annual O&M costs for 28 systems was $418,000 and $424,000, respectively (NFESC 2003), while annual O&M costs for Superfund sites in USEPA Region 6 range from $180,000 to $500,000 (USEPA 2001a).

6.1.4 Injection Well Disposal

Class I injection well disposal is a containment/treatment technology that involves the injection of contaminants into an injection zone below the underground source of drinking water (between 2,200 and 12,000 feet deep along the Gulf Coast). The injection zone is overlain by a relatively nonpermeable layer of rock, known as the confining zone. The confining zone holds the injected contaminated groundwater in place and restricts it from moving vertically towards a drinking water supply well. Class I wells are designed and constructed to prevent the movement of injected

wastewater out of the injection interval and into the underground source of drinking water (USEPA 2001b).

An injection well remedy has not been implemented at any of the comparable Superfund Sites due to costs for transporting and disposing of wastes at a commercial underground injection well facility.

The advantages of injection well disposal are:

1. Safe disposal of contaminated liquids with minimal pretreatment (usually filtering);
2. Availability of a system at the MSC Superfund Site; and
3. Applicability to numerous organic and inorganic chemical contaminants, and unrestricted by aqueous concentration limits.

The disadvantages of the system include:

1. Tendency for the well infiltration galleries to become plugged, which reduces the well efficiency and increases the cost of maintenance;
2. Failure of the packers separating the injection zone from the confining zone;
3. Corrosion or leaks in the casing or tubing requiring periodic workovers;
4. Costs of routine Mechanical Integrity Testing and periodic injection interval testing; and
5. Although limited, there still exists a possibility of further contaminating the aquifer once the contaminated groundwater is injected.

6.2 Sludge and Soil

Remedial technologies considered for the treatment of sludge and soils include incineration, solidification/stabilization, capping and biological treatment such as bioslurries or landfarms.

6.2.1 Incineration

Incineration uses flame combustion to volatilize and destroy organic contaminants in soils, sludges, liquids and gases. Incineration was chosen and implemented as the primary remedial technology at the Sikes Superfund Site, the MOTCO Superfund Site and the Brio Superfund Site. Incineration was also chosen as the primary remedial technology at the French Limited Superfund Site, but the remedy was changed due to a successful demonstration of bioremediation. Incineration at both the MOTCO and Brio Superfund Sites was not completed due to technical difficulties and community concerns.

Typically, hazardous waste incinerators operate at 1,200 °F to 3,000 °F (USEPA 1998b). An incinerator consists of a burner, which ignites the supplied fuel and combustibles in the waste feed, a primary combustion chamber or kiln, a secondary combustion chamber (SCC), which incinerates the products of incomplete combustion or liquids, and an air pollution control system. Two primary

incinerator types have been used as a remedy at Superfund sites: rotary kiln incinerators and liquid injection incinerators. Rotary kilns treat most forms of water, including solids, liquids, sludges and debris. Rotary kilns are cylindrical, refractory lined steel shells that rotate on a horizontal axis. Liquids injection incinerators are used to treat combustible liquid and liquid-like wastes, including sludges and slurries.

Performance standards for an incineration system are determined during a trial burn. During the trial burn, the system is operated at worst-case conditions and the destruction and removal efficiency of the incinerator for the principal organic hazardous constituents is measured. During the trial burn, the system must meet applicable emissions limits.

The advantages of incineration for treatment of waste streams is:

1. Removal of contamination above ROD cleanup levels;
2. Successful treatment/detoxification of liquid and solid hazardous wastes;
3. Shorter time-frame to complete remedial action than with other treatment technologies such as bioremediation; and
4. No long-term operation, maintenance or monitoring required.

The disadvantages of incinerator for treatment of waste streams is:

1. Community concerns over noise and emissions;
2. Changes in waste feed composition affects materials handling and operating efficiency of system;
3. Slagging due to the presence of unacceptably high concentrations of inorganic contaminants or minerals in the waste feed;
4. Handling of residuals (ash, salts, and scrubber water);
5. Weather delays (cold, strong storms, excess heat); and
6. Shut down of incinerator due to overpressurization of kiln.

The total unit costs (including pretreatment of waste streams and management of residuals) for eleven Superfund sites ranged from $230 per ton to $3,300 per ton. The average cost for these sites was $1034 per ton and the median cost was $540 per ton. The average costs were influenced by the two sites, including the MOTCO Superfund Site, which had numerous mechanical and operational problems. The lower costs were attributed to using larger incinerator (Sikes Superfund Site) and raising the residual criteria for dioxins and furans that reduced residence time and increased throughput (Old Midland Superfund Site in Ola, Arkansas).

6.2.2 Solidification/Stabilization

Solidification/stabilization is a containment or treatment technology implemented by mixing a reagent,

such as organophilic clay, Portland cement, kiln dusts or fly ashes, lime, or bentonite into contaminated soil or sludge. Stabilization generally refers to a chemical binding process that binds the matrix so that the contaminants are immobilized while solidification refers to a mechanical process where a semi-solid material or sludge is treated to render it solid with little or no free water.

Solidification and/or stabilization has been chosen as the primary remedy for soils at the Dutchtown Treatment Plan, Gulf Coast Vacuum Services, Mallard Bay Landing, MOTCO, PAH Oil and Chemical Service and Sheridan Disposal Services Superfund Sites. Solidification/stabilization was chosen as the primary remedy for the Bailey Waste Disposal Site, however, after the contractor experienced difficulties meeting the specifications, the ROD was amended for a more stringent cap design.

This technology is used for metals and organic wastes (except low molecular weight organics) and can be used to treat concentrations of contaminants up to 8,400 ppm pentachlorophenol, 2,000 ppm arsenic, 2,000 ppm chromium, and 1,500 ppm copper. This technology has been demonstrated to remove between 80% to 97% of pentachlorophenol, 98% of arsenic, 86% to 90% of copper, and 54% of chromium (USEPA 1992).

A treatability study is typically performed using representative sludge and soils during the RI/FS. The objective of the study is to:

1. Determine the most economical mix design;
2. Identify materials handling problems;
3. Identify the nature and extent of volatile emissions during processing;
4. Assess the physical and chemical uniformity of the waste; and
5. Determine the volume increase associated with treating soils, sludge, and wastes.

Once an optimum mix design is demonstrated with physical tests such as weight-bearing tests or unconfined compressive strength, the solidified /stabilized material is subjected to leaching tests to demonstrate immobilization of the contaminants.

The advantages of the solidification/stabilization technology are:

1. Well understood and accepted technology.
2. Well established procedures for evaluating the effectiveness of the technology.
3. Effective for immobilizing metals.
4. Short-time frame to implement technology compared to other technologies.
5. Easy to implement in conjunction with other technologies, such as landfilling or capping in place.

The disadvantages (USACE 1995; USEPA 2002e) of the solidification/stabilization technology are:

1. Contaminants typically remain on-site.

2. High concentrations of organic contaminants, particularly volatiles, may require thermal, biological, or other treatment prior to solidification/stabilization.
3. The risk of worker or public health exposure to sludge contaminants and volatile emissions during handling.
4. Changes in sludge physical and chemical characteristics may increase the mobility of particular contaminants.

The total cost to implement a solidification/stabilization system can range from about $200 to $300 per cubic yard of sludge. The average operational time to treat 1,000 yd^3 of waste was 1.1 months (USEPA 2000b).

6.2.3 Capping

Capping is a containment technology that reduces the mobility of wastes by applying impermeable materials over the waste. Hazardous waste applications can utilize a RCRA Subtitle C cap, or depending on the nature of the wastes and site conditions, a less rigorous cap design. For example, less rigorous cap designs may be sufficient to minimize runoff of contaminants to surface water compared to cap designs needed for impoundments that contain liquids or sludges. The RCRA Subtitle C cap is composed of a minimum of three layers: 1) an uppermost vegetation/soil layer, underlain by a minimum of 24 in. of compacted soil sloped between 3 and 5 percent; 2) a drainage layer, a minimum of 12 in. of sand, underlain by a flexible membrane liner to convey water out of the cap; and 3) a lowermost moisture barrier, a minimum of 24 in. of compacted clay, to prevent infiltration. The permeability of the compacted clay layer should be less than $1x10^{-7}$ cm/sec.

While capping of treatment residuals was a component of almost every remedy, the primary remedy for source control at four sites (Bailey Waste Disposal, Old Inger Oil Refinery, and Petro-Processors of Louisiana) was a cap.

The advantages of capping are:

1. Minimization of ingestion, inhalation, and direct contact exposure of human and ecological receptors to waste materials.
2. Reduction in mobility of waste.
3. Prevention of the vertical infiltration of water into wastes and reduces the creation of contaminated leachate.
4. Control of VOC emissions from waste.
5. Creation of a land surface that can support vegetation; however deep-rooted vegetation will interfere with the integrity of the cap.
6. Caps can be used in conjunction with other remedies such as barrier walls or

solidification/stabilization.

The disadvantages of capping are:

1. Contaminants remain on-site and the toxicity and volume of the waste is not reduced.
2. Long-term inspection and maintenance of the cap is required.
3. Caps are not as effective if most of the underlying waste is below the water table.
4. Performance is a function of quality construction more than materials so construction quality assurance is critical.

Several treatability studies are needed prior to designing a cap to cover hazardous wastes. The compatibility of wastes with the cap materials must be evaluated. Candidate soil sources must be evaluated for compaction characteristics, shear strength, and hydraulic conductivity (USEPA 2004q).

The costs of installing a RCRA cap can be between $200,000 to $1,000,000 per acre for a RCRA Subtitle C cap. The installation time for the cap ranges from 1 to 4 months while active monitoring and maintenance can go up to 20 years (USDOE 2003).

6.2.4 Bioremediation

Bioremediation technologies reduce the volume, toxicity and mobility of wastes by utilizing microorganisms to treat contamination. Bioremediation of soils and sludge can be performed in-situ (in place landfarming, bioventing or bioslurries) or ex situ (engineered land treatment, biovaults). Slurry-phase treatment is particularly suited to remediation of sludge with a high water content while landfarming is more suited to the treatment of soils or sludge with a low water content.

Bioremediation was chosen as the primary remedy for the French Limited, Gulf Coast Vacuum Services, Oil Inger Oil Refinery and Petro-Chemical Systems (Turtle Bayou) Superfund Sites.

Bioslurry reactors include lagoons or vessels that contain a mixture of contaminated soil/sludge and water at a soil/sludge-water ratio ranging from 5% to 50% by weight. Effective use of slurries results in contaminant solubilization, mixing improvement, mixing energy requirement reduction, media homogenization, and mass transfer improvement. Indigenous microorganisms in the soil/sludge biodegrade the contaminants in the reactor. It may be necessary to add nutrients and control the pH, temperature, aeration, and mixing requirements to achieve the desired performance.

Bioslurry reactors can treat a wide variety of wastes including wood treating wastes, PAHs, oil separator sludge, petroleum hydrocarbons, PCBs, and vinyl chloride. Contaminant concentration reductions of about 98% for pesticides/herbicides, 97% for fuel and oil, 84% for PAHs and creosote, 96% for PCBs, and 92% for explosives have been reported.

Treatability studies should be performed prior to implementing the bioslurry remedy. Treatability studies allow the flexibility of investigating a range of environmental variables such as pH, alkalinity,

temperature, and nutrient addition, all of which can affect performance and be controlled in the field when using the appropriate technology.

One of the disadvantages to using a bioslurry reactor system is the cost. The repair and replacement costs can be expensive because of the wear and tear on the equipment caused by mixing the sludge slurries. Mixing slurries is also energy intensive and will increase costs while aeration expenses can also be a major cost constituent. Post treatment dewatering, secondary wastewater treatment, and solids disposal may be required, therefore significantly increasing overall treatment costs. Bioslurry reactors also require more careful monitoring and more intensive operations and maintenance compared to other land treatment options. Monitoring and control of pH, nutrients such as nitrogen and phosphorus, soil moisture content is required to effectively reduce contaminant concentrations.

The cost of a bioslurry reactor system ranges from $97 to $335 per cubic yard of sludge treated. The costs for the slurry-phase treatment of 300,000 yd^3 of sludge and soils at the French Limited Superfund Site were estimated at $90 per cubic yard (the cost in Table 14 is normalized to the original sludge volume estimate).

The timeframe to complete the process can be between a couple of months to a year (USEPA 2002f).

6.2.5 Landfarming

Landfarming/Land Treatment is an aboveground remediation technology for soils that reduces the concentrations of contaminants through biodegradation. This technology involves in place or ex situ spreading of excavated contaminated soils in a thin lift over the ground surface. Aeration and/or adding minerals, nutrients, and moisture may be necessary to stimulate microbial activity within the soils. The construction of a landfarm site involves site preparation (grubbing, clearing, and grading), constructing berms, liners, and a leachate collection system, site enclosures, and appropriate vapor treatment facilities, if needed. The contaminated soil may have to be pretreated by shredding, blending, and adding amendments. The landfarming aeration, and fertilizer and waste mixing are all accomplished by tilling the soil with common farm implements. Water is added as needed by sprinkling.

Landfarming is effective for petroleum constituents with concentration up to 50,000 ppm total petroleum hydrocarbons (TPH) and heavy metals with concentration up to 2,500 ppm. If the concentrations of TPH exceed 10,000 ppm, the contaminated soil may have to be blended with clean soil to reduce concentrations to levels that are not toxic or inhibitory to microbial growth. For TPH concentrations less than 50,000 ppm, landfarming can effectively reduce TPH concentrations up to 95% to meet a cleanup requirement of 0.1 ppm (USEPA 2004r).

One of the disadvantages of landfarming is that the process requires a large amount of land area. Concentration reduction greater than 95% and a remedial objective of less than 0.1 ppm as TPH is difficult to achieve. This technology may not be a good choice for TPH concentrations greater than

50,000 ppm and heavy metals concentrations greater than 2,500 ppm. Volatile constituents also tend to evaporate instead of biodegrade during treatment. In addition to that, dust and vapor generation during landfarm aeration may pose air quality concerns.

The primary advantages of using land treatment (USEPA 2002f) include:

1. The process is destructive with the contaminants being transformed into innocuous end products.
2. The system can be covered and left dormant over winter months during low biological activity.
3. Monitoring allows for control of contaminant migration.
4. The cost of land treatment is usually lower than alternatives such as incineration or hauling and disposal in a secure landfill.
5. Following remediation, the site can be converted to beneficial uses.

The primary limitations of land treatment include:

1. Land treatment is land and management intensive.
2. Climatic conditions strongly affect biodegradation.
3. Metals may accumulate in the treatment area
4. Certain wastes may be land banned.
5. Lift depth is limited by depth of tilling.
6. Volatile emissions and/or dusts can be a nuisance and may pose a health threat.
7. Improper design and/or operation can result in an adverse environmental impact such as enhanced leaching to groundwater.
8. Area required to implement technology may be extensive.

Remediation times are often years, depending mainly on the degradation rates of specific contaminants, site characteristics such as available treatment area, and climate. Less than one year may be required to clean up some contaminants, but higher molecular weight compounds take longer to degrade (USEPA 2004s).

The cost of landfarming can range from about $12 to $500 per cubic yard of contaminated soil with most unit costs less than $300 per cubic yard (USEPA 2001c). Other cost estimates range from $30 to $50 per cubic yard (USEPA 2002f).

6.3 Sediments

Technologies applicable to the treatment of contaminated sediments include passive processes such as siltation (deposition of clean sediments) and active process such as dredging.

6.3.1 Siltation

Passive re-siltation for contaminated sediments involves installing barriers to redirect or slow the flow of water through a marsh area, thereby causing a decrease in sediment suspension allowing clean silt to deposit over the contaminated sediment. Siltation is an effective process when coupled with source control (such as runoff from contaminated soils or discharge of contaminated surface water) is limited and contaminant concentrations and risk to public health and the environment are low. Siltation will bury or dilute existing contaminants and prevent exposure of the contaminated sediment to invertebrate organisms, omnivorous mammals, and humans, while immobilizing the contaminated sediments. To accomplish this, a detailed map of contaminant distribution in surface sediment is needed to define initial conditions. Current and tidal dynamics must also be assessed to determine if this is a viable alternative.

Siltation was the remedy chosen for Operable Unit 4 of the TexTin Superfund Site (USEPA 2001d). In addition, natural siltation processes at the Petro-Processors of Louisiana site are used for the contaminated sediment remedy. The sediments are monitored for natural restoration (USEPA 2004n).

The estimated capital cost for a passive re-siltation process utilizing segmented wave barriers for the TexTin Superfund Site was about $5,000,000 while operations and maintenance cost was approximately $800,000. This brings the total cost of a passive re-siltation system to about $7,000,000 (including $1,000,000 for contingency). The construction timeframe for this type of system is about nine months. Although the construction timeframe is relatively short, the total time taken to reduce the concentration level to site remedial goals may take a much longer time (USEPA 2001d). The TexTin remedy was constructed by the Corps of Engineers for USEPA, and was reported completed under the ROD estimate (Puga 2004).

Active re-siltation is very similar to passive re-siltation except that in active re-siltation, water mixed with clean silt or other sediment-like material is pumped through or discharged into the contaminated site and allowed to deposit over the contaminated sediment. Similar to the passive re-siltation process, active re-siltation buries or dilutes the contaminant in the sediment, reducing the concentration over time.

6.3.2 Dredging

Environmental dredging involves removal of contaminated sediment from a water body (USEPA 1998c). Dredging is applicable to sites with high concentrations of contaminants or risk to human health and the environment. After the contaminated sediment is excavated and removed, it has to be treated or disposed of in a proper manner. Some of the management options for dredged sediment are placement in a confined disposal facility, disposal in a permitted landfill, or treatment in a separate treatment facility. Treatment can result in the formation of residuals that eventually have to be removed. Most of these require an accompanying dewatering step.

Contaminated marsh sediments were removed from the Bailey Waste Disposal site and placed in a Class 1 landfill while contaminated sediments at the Petro-Processors of Louisiana site were remediated and backfilled.

Advantages to dredging are:

1. Removes the contaminated sediments permanently so is protective.
2. Mechanically simple with dredging equipment readily available.

Disadvantages to utilizing dredging are:

1. Dredging can be very expensive depending on the amount of contaminated sediment that has to be excavated.
2. Dredging can resuspend or redissolve contaminants and this material can be transported away from the site.
3. Pre-treatment and post treatment disposal may be required.
4. Increases the chance for the site workers to contact the contaminated material.
5. Dredging can be more destructive than the problem it seeks to address.
6. Complicated and/or expensive dewatering is required for some sites.

The cost estimate for excavating/dredging contaminated sediments from the Swan Lake Marsh and Swan Lake ranged from $17 million to $33 million or approximately $143 per yd^3. The estimates varied based on the volume required to meet different remedial action objectives. In both cases it was assumed that the sediments would be disposed of in a non-hazardous waste landfill, the area would be backfilled with clean fill and revegetated to reestablish the marsh and wetlands (USEPA 2001d).

7.0 PRESUMPTIVE REMEDY

One of the goals of this PRAER is the development of a presumptive remedy(ies) for affected media at the MSC Superfund Site. This document does not eliminate the evaluation of other remedial alternatives during the FS if data developed during the RI indicate that other technologies may be more suitable for the site contaminants. The presumptive remedy(ies) are selected using data and experience from the MSC Superfund Site and from other Superfund or related waste sites with similar settings, histories, and contaminants to eliminate remedial alternatives.

This section of the PRAER will focus on those remedial alternatives that were:

- selected and successfully implemented at site(s) similar to MSC; or
- were considered but were not selected and the reasons for eliminating the alternative are not applicable to MSC.

Affected media at the MSC Superfund Site include sludge and waste materials located in the pits, API separators and tanks at the site as well as groundwater. Potentially affected media include on-site soils, sediments, and marsh sediments located outside the site between the flood protection levee and Swan Lake. A proposed remedy for Swan Lake is not included in this document because a remedy for this water body was implemented in Operable Unit 4 of the TexTin Superfund Site.

The PRAER will discuss in this section, at a minimum, remedial alternatives and technologies that comply with the NCP requirements that containment, treatment and no-action alternatives be developed and considered in the FS (USEPA 1988a).

The conceptual site model for the MSC Superfund Site reflects similarities and dissimilarities with most of the sites selected for comparison. Generally, the possible exposure sources and transport media were similar. For the MSC Superfund Site, the potential for exposure appears to be less due to lower potentials for contact and uptake in general. This includes mitigating factors such as remote location, lack of drinking water wells nearby, containment by a hurricane levee, and containment of stormwater within the hurricane levee. Typically, source and media issues can be addressed by either containment or treatment.

Four details unique to the MSC Superfund Site were considered during the development of the presumptive remedy(ies). (1) The MSC Superfund Site has considerably more waste material potentially requiring treatment than other Superfund sits evaluated in this document; up to 350,000 yd^3 versus 59,100 to 76,000 yd^3. (2) PCBs, which limited the remedial options for the French Limited and MOTCO Superfund Sites, have not been detected in waste or soil samples. (3) The MSC Superfund Site has an operable underground injection well available for incorporation into the remedies. Injection wells, as a component of a remedial alternative, was considered for three sites, but eliminated due to the costs of disposal at a commercial underground well injection facility. (4) The MSC Superfund Site is already protected with a hurricane levee, gate(s) and a drainage system capable of controlling off-site

stormwater drainage.

7.1 Sludge, Waste Materials, and Soils

Treatment alternatives suitable for the waste materials at the MSC Superfund Site include incineration, solidification/stabilization, bioremediation, and solidification/stabilization, while suitable containment alternatives include an on-site cap or off-site disposal in a landfill.

7.1.1 No Action Alternative

The no-action alternative for the sludge and waste materials at the MSC Superfund Site was evaluated and eliminated as a potential remedy. The presence of the sludge and waste materials requires access to the site be limited to minimize exposure to public health and prevents redevelopment of the property. The sludge and waste materials, due to their presence in one or more impoundments within a permeable paleochannel, provide a continuing source for the migration of chemical contaminants to groundwater. The presence of sludge and wastes within the pits and impoundments poses a potential threat to ecological receptors that may enter or otherwise use the pits for shelter or food sources. Although the sludge and waste materials are contained within impoundments, pits and tanks, a tropical storm or hurricane could wash the wastes out of the impoundments and pits and could overwhelm the stormwater management system. A tank failure could also release the contained wastes to the site. The release of sludge and waste materials to site soils and sediments would increase the impact to ecological and human receptors, increase the potential for migration to groundwater, and increase the amount of affected media requiring remediation for property redevelopment or reuse. The potential for off-site migration is limited by the flood protection levee and the closed stormwater outfall.

7.1.2 Treatment Alternatives

Both **on-site incineration and off-site incineration** were considered at all screening example Superfund sites except for the Highlands Acid Pit and Petro-chemical Systems (Turtle Bayou), fourteen of sixteen sites. Incineration was the chosen remedy for the three Superfund sites, MOTCO, Brio Refining and the French Limited Superfund Site, as well as the Dutchtown Treatment Plant and the Sikes Disposal Pits Superfund Site. Incineration was successfully implemented only at the Sikes Disposal Pits Superfund Site because much of the waste materials were tar-like materials with low water content. Incineration was not successfully implemented at the MOTCO Superfund Site because of technical difficulties with handling the sludge and waste materials, inadequate utilities service and inadequate characterization of wastes. Incineration was not successfully implemented at the Brio Refining Superfund Site because the volatile emissions from waste handling operations significantly increased health risks to nearby residents and on-site workers. Public opposition to the incineration remedy at both the MOTCO and Brio Refining Superfund Sites was organized and vocal. Incineration was initially chosen as the remedy for the French Limited Superfund Site, but the FLTG successfully

demonstrated the cost effectiveness and technological effectiveness of bioremediation. The initial incineration remedy at the Gulf Coast Vacuum Services Superfund Site was also modified to bioremediation of sludge.

Solidification/stabilization was evaluated as the remedy for six sites and chosen at seven sites. The remedy was not chosen for sites with high concentrations of organics. The contractor had difficulties meeting the solidification/stabilization specifications for the Bailey Waste Disposal Pits Superfund Site and after a focussed feasibility study, the ROD was amended to off-site disposal of waste material from the marsh area and consolidation and capping of the remaining wastes. The stabilization remedy for the Dutchtown Treatment Plant, the Gulf Coast Vacuum Services and the MOTCO Superfund Sites was limited to the soils media. Approximately 7,000 yd^3 of soils and sludge at the PAB Oil and Chemical Service Site were successfully solidified using a mixture of cement, ferrous sulfate, and organophilic clay to meet the remedial action objectives for arsenic and barium. The in-situ stabilization/solidification remedy at the Sheridan Disposal Services Superfund Site has not been implemented. Attempts to dewater the sludge in the MSC Superfund Site API separators with various amendments were unsuccessful in past treatability studies or on-site pilot studies.

Bioremediation of sludge to treatment standards was successfully implemented at the French Limited Superfund Site, the Gulf Coast Vacuum Services Site, the Old Inger Oil Refinery Superfund Site, and portions of the Petro-Chemical Systems (Turtle Bayou) Superfund Site. Approximately 300,000 tons of sludge and soils at the French Limited Superfund Site and 58,000 tons of PAH contaminated materials at the Old Inger Oil Refinery Superfund Site were remediated. A treatability study on aeration/biological degradation and aeration/settling for the MSC Superfund Site impoundment waste indicated that aeration and biological degradation were effective in reducing the COD concentrations by 60% after 14 days and 80% after 35 days (ECA 1989b).

7.1.3 Containment Alternatives

Capping was implemented as a remedy for both the Brio Refining and MOTCO Superfund sites after the unsuccessful implementation of the original incineration remedy. The cap remedy at these sites was accompanied by the installation of a slurry wall to contain groundwater contaminants. Slightly contaminated soils and sludge and bioremediated materials were capped at the Old Inger Refinery Superfund Site.

In 1983, considerable quantities of sand were placed in the eastern one-third and southwestern corner of the Sludge Pit and over the Oil Pit contents at the MSC Superfund Site (ECA 1989a). Geotextile fabric was installed to cover the impoundment contents in both the Sludge Pit and the Oil Pit. There has been substantial settling of the cap material in the Oil Pit and stained areas can be seen on top of the soil cap. Several months after closure activities ceased, the geotextile fabric in the Sludge Pit reportedly tore, thereby reportedly allowing waste material to flow to the top of some of the sand in the eastern one-third of the sludge pit. This indicates that a cap of the sludge and waste material in the

pits without pretreatment is likely to fail.

Approximately 22,000 yd^3 of waste material and soil from the Highlands Acid Pit Superfund Site was excavated and disposed off in a permitted Class 1 hazardous **landfill** facility. Capping of soil and waste materials was not chosen because of the dynamic hydrologic setting. The site was located within the San Jacinto River floodplain and several flooding events over the 30-year period were anticipated. The flood events could have caused erosion of the cap and deposition of waste materials in the river system. In addition, subsidence in the area due to groundwater removal had been substantial; subsidence would cause the cap to crack.

Offsite soils along a public road adjacent to the Petro-Chemical Systems (Turtle Bayou) Superfund Site were excavated and placed in an on-site RCRA vault. The USEPA remedy requires that these soils be removed from the vault and remediated with the on-site soils.

7.1.4 Remedy

The recommended presumptive remedy for sludge, wastes and soils has several components:

1. Bioremediation of the sludge in the Sludge and Oil Pit, API separators and tanks to reduce volume and toxicity.
2. Injection of the treated related water into the underground injection well.
3. Solidification and stabilization of the residuals in the sludge pit.
4. Capping the solidified/stabilized residuals, possibly along with contaminated soils, and
5. Maintenance of the existing hurricane levee and controlled stormwater drainage system.

The limited soils data for the site indicate that soil contaminants are primarily hydrocarbon-related chemicals such as PAHs. Assuming this chemical profile is confirmed during the RI, three alternatives for soils contaminated above risk levels are proposed. The appropriate alternative will be determined based on the volume of material requiring treatment and the concentrations of the contaminants.

1. In-situ treatment of soils (e.g., landfarm) followed by covering the treated soils with a soil cap;
2. Excavation and incorporation of the soils into the sludge and waste bioremediation systems; or
3. Excavation and consolidation of the soils with the solidified/stabilized residuals, and
4. Maintenance of the existing hurricane levee and controlled stormwater drainage system.

The following activities are recommended during the RI/FS to determine the suitability of the presumptive remedy for the sludge, wastes and soils:

1. Obtain samples of wastes and sludge from the Oil Pit, Sludge Pit, API separators, and tanks and conduct biotreatability studies.

2. Determine mixing protocol and specifications for residual.
3. Sample surface soils (0-6") within the lay down area, the undeveloped area south of the offices and earthen impoundment, the decanning area, the tanks, and the area south of the Unit 1200 API separator.

7.2 Groundwater

Treatment alternatives suitable for the groundwater at the MSC Superfund Site include pump and treat, MNA, and bioremediation, while suitable containment alternatives include a vertical barrier wall and deep well injection.

Four elements were significant to the development of a presumptive remedy for the MSC Superfund Site. (1) Historical data, though approximately 10 years old, indicate that impacted groundwater has not advanced beyond the site boundaries. (2) The site is relatively isolated and drinking water wells are not located within one-mile of the site. (3) An aggressive remedy has been recommended for the sludge, wastes and soils at the site. (4) The site's operable underground injection well is available for incorporation into the remedies.

7.2.1 No-Action Alternative

The no-action alternative for the groundwater at the MSC Superfund Site was evaluated and eliminated as a potential remedy. Even if impacted site groundwater is still contained within the site, there is no guarantee that already impacted groundwater will not migrate off-site.

7.2.2 Treatment Alternatives

MNA and pump and treat were the most frequently chosen groundwater remedies at the sites screened. At the French Limited Superfund Site, active pump and treat combined with in-situ bioremediation was used to lower the contaminant concentrations to levels that were expected to naturally attenuate to protective levels by 2005. At MOTCO, a pump and treat approach was used but only to the extent that extracted groundwater maintained an inward gradient to the containment system. Brio actively pumps and treats groundwater to facilitate the containment of groundwater as well as to treat localized high concentrations.

Five-year reviews for six sites indicated that MNA was protective at three sites, the Dutchtown Treatment Plant Superfund site, the PAB Oil & Chemical Superfund Site, and the Petro-Chemical Systems (Turtle Bayou) Superfund Site. However, at three sites, five-year reviews indicated that MNA may not be protective of the sites. The five-year review for the French Limited Superfund Site stated that localized areas within the site may not attain compliance standards by the end of the 10-year monitoring period (2005) (USEPA 2002d). At the Gulf Coast Vacuum Services Superfund Site, the second five-year review stated that COCs exceeded MCLs and did not show decreasing trends (Tetra

Tech 2003). The second five-year review for the Highlands Acid Pit Superfund Site stated that concentrations of site-related contaminants increased in middle and deep aquifers (USEPA 2002b).

7.2.3 Containment Alternatives

A vertical barrier wall (slurry wall) was chosen as the containment remedy for the MOTCO and Brio Refining Superfund Sites. A sheet pile wall was installed as a containment remedy at the French Limited Superfund Site. The vertical barrier walls were installed to manage the migration of contaminated water but did not treat the affected groundwater. Instead, as discussed above, containment remedies were accompanied by pump and treat systems to maintain a hydraulic head toward the inside of the containment system. This effectively minimizes treatment volumes and lessens the chance that contaminants will slowly migrate outside the containment.

7.2.4 Remedy

The recommended presumptive remedy for groundwater has three components:

1. Installation of a slurry wall in the sand channels on either side of the Sludge Pit.
2. Maintenance of an inward gradient by pumping the groundwater inside the slurry wall and injection of the treated water into the underground injection well.
3. Monitored natural attenuation of groundwater outside the slurry wall.

This remedy is supported by the unique MSC Superfund Site characteristics discussed in Subsection 7.2.

The following activities are recommended during the RI/FS to determine the suitability of the presumptive remedy:

1. Determine the extent of horizontal migration in the first transmissive zone by sampling all on-site monitoring wells for metals, SVOCs, and VOCs.
2. Verify the boundaries of the paleostream sand channel by determining the stratigraphy using cone penetrometer tool techniques.
3. Develop geotechnical data for slurry wall placement using the cone penetrometer tool (CPT) techniques, intact cores, or other methods as needed for slurry wall design and placement.

7.3 Sediments

The only identified treatment alternative for the site is bioremediation of sediments containing organic compounds exceeding risk-based criteria. Containment alternatives suitable for the MSC Superfund Site include dredging and disposal in the capped area or in-situ capping using passive or active siltation.

Two elements were significant to the development of a presumptive remedy for the MSC Superfund Site. (1) Sediments in the on-site ditches were excavated during the START activities (Zehner 2004). (2) The existing remedial action for Swan Lake was recently completed as part of the TexTin Superfund Site Operable Unit 4 (Puga 2004).

7.3.1 No-Action Alternative

The no-action alternative for the sediments at the MSC Superfund Site was evaluated and retained as a potential remedy. Since on-site sediments were removed by the USEPA, additional remediation activities may not be warranted. Off-site sediments in Swan Lake are currently being remediated by the TexTin remedy and thus no further action is required for those sediments.

7.3.2 Treatment Alternatives

Bioremediation of hydrocarbon-contaminated sediments is a proven technology. However, bioremediation of sediments can be more disruptive or damaging than no-action. Treatment should be considered only if the no-action alternative appears unable to practically remediate the sediments.

7.3.3 Containment Alternatives

Containment remedies for sediments include placement of an in-situ cap over the contaminated sediments, stabilization of the contaminated sediments followed by removal of the stabilized material and placement under a cap followed by replacement of the sediment, or by siltation over the stabilized material left in place. Both processes are destructive of any benthic organisms in the sediment and should be used only if less destructive remedial approaches are not practical or can not restore the habitat.

7.3.4 Remedy

The recommended presumptive remedy for sediments has two components:

3. No action for on-site sediments.
4. Natural siltation for off-site sediments in the marshy area east of the site between the flood protection levee and Swan Lake under the existing implemented TexTin OU-4 Remedial Action.

The following activities are recommended during the RI/FS to determine the suitability of the presumptive remedy:

1. Augment the sediment data from the SSI (TNRCC 1998) with additional samples from the marshy area adjacent to the storm water discharge and from the on-site drainage ditches.
2. Assess the presence and bioavailability of metals in the pond and, if needed, the pond and the off-site area near the stormwater discharge using acid volatile sulfide-simultaneously extracted metals

and total metals analyses.

8.0 PRELIMINARY ARARS

Section 121 (d)(2)(A) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA), incorporates into the law the CERCLA compliance policy. This policy specifies that Superfund remedial actions meet any Federal standards, requirements, criteria, or limitations that are determined to be legally applicable or relevant and appropriate requirements (ARARs). Also included is a provision requiring that State ARARs be met if they are more stringent than Federal requirements but only to the point where state ARARs are consistently enforced. The purpose of this requirement is to make CERCLA response actions consistent with other pertinent Federal and State environmental requirements. This section identifies the potential state and federal action-specific, chemical-specific, and location-specific ARARs that may be applicable to the RI and remedial action for the MSC Superfund Site. In addition, this section discusses the to-be-considered (TBC) advisories, criteria, and guidelines.

8.1 Action-Specific ARARs

Action-specific ARARs are usually technology or activity-based requirements or limitations on action taken with respect to hazardous waste. These ARARs may set controls or restrictions on the particular treatment and disposal activities implemented at the MSC Superfund Site. These requirements are triggered by the particular remedial activities that are selected to accomplish a remedy. Action-specific ARARs are generally not finalized until the development of alternatives in the FS. The action-specific ARARs listed in this document are generic and will be refined as the steps in the FS process are completed. Table 20 summarizes the preliminary ARARs for the presumptive remedies discussed in this document.

8.2 Chemical-Specific ARARS

Chemical-specific ARARs are usually human health or ecological risk-based numerical values. The values may define acceptable exposure levels and may serve as the basis for establishing preliminary remediation goals. The values are derived from published tables or by methodologies, which applied to site-specific conditions, result in the establishment of numerical values. If a chemical has more than one ARAR requirement, the more stringent requirement applies. A description of the potential COCs and the affected media are required to finalize the chemical-specific ARARs. Table 21 summarizes the preliminary ARARs for the chemicals detected at the MSC Superfund Site.

8.3 Location-Specific ARARS

Location-specific ARARs are restrictions placed on the concentration of hazardous substances or the implementation of activities based solely on specific locations. Examples of specific locations that may require the development of ARARs, include floodplains, wetlands, historic places, cemeteries,

and sensitive ecosystems or habitats. Location-specific ARARs are refined after the site's physical features are identified and finalized after the evaluation of the remedial technologies. Table 22 summarizes the location-specific ARARs for the MSC Superfund Site.

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TABLES

Table 1 Comparison of Source Characteristics and Maximum Concentrations

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Surface Area (acre)	5[a]	21.6	7	4.55
Maximum Depth (ft)	40[a]	15.4	10.5	15 – 20
Water Volume (gallons)	NA	NA	2.5E+06	5.7E+06
Waste Volume (yd^3)	337,000[b]	63,000	70,000	59,100
Water Content (%)	NA	50.7 (avg)	26.87 (avg)	11.35
Flashpoint (F)	125 – 185	> 250	170	160 –180
BTU/lb (average)	826 – 8340	NA	1447	4100 – 15600
pH (units)	5 – 7.7	6.4 – 8.5	5.6 – 8.8	1.5 – 5.5
Acetone, mg/Kg	1130	NA	110	NA
Benzene, mg/Kg	1900	242	270	5440
Butanone, 2- (MEK)	1240	NA	NA	NA
Carbon tetrachloride	202	NA	NA	NA
Chlorobenzene, mg/Kg	440	1150	16	400
Chloroform, mg/Kg	200	4690	230	800
Cumene, mg/Kg	700	NA	NA	NA
Dibromochloromethane, mg/Kg	1420	NA	NA	NA
Dichloro-2-butene, trans-, mg/Kg	750	NA	NA	NA
Dichloroethane, 1,1-, mg/Kg	190	5480	150	3200
Dichloroethane, 1,2-, mg/Kg	3740	245,000	348	41,500
Dichloroethene, 1,1-, mg/Kg	281	1570	2	10,000
Dichloroethene, trans-1,2-, mg/Kg	ND	8130	200	11,200
Ethylbenzene, mg/Kg	4900	3370	380	6000
Hexanone, 2-, mg/Kg	27.6	NA	NA	NA
Methylene chloride, mg/Kg	4700	1000	170	90
Methyl-2-pentanone, 4-, mg/Kg	1500	NA	980	NA
Styrene, mg/Kg	4980	NA	330	22,000
Tetrachloroethene, mg/Kg	11,000	1180	120	900
Tetrachloroethane, 1,1,2,2-, mg/Kg	658	NA	NA	4000
Toluene, mg/Kg	9900	186	420	3200

Table 1 Comparison of Source Characteristics and Maximum Concentrations

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Trichloroethane, 1,1,1-, mg/Kg	39,000	NA	55	NA
Trichloroethane, 1,1,2-, mg/Kg	2730	166,000	NA	61,000
Trichloroethene, mg/Kg	7300	3650	44	400
Trichlorotrifluoroethane, mg/Kg	2043	NA	NA	NA
Vinyl chloride, mg/Kg	ND	22,700	69	7600
Xylenes, total, mg/Kg	42,000	NA	430	3000
PCB (Total), mg/Kg	ND	NA	45 (average)	100
Acenaphthene, mg/Kg	550	5	4100	1300
Acenaphthylene, mg/Kg	960	< 15	2000	6000
Anthracene, mg/Kg	550	921	4400	8430
Benzidine, mg/Kg	7000	NA	NA	NA
Benzo(a)anthracene, mg/Kg	1150	18	740	3000
Benzo(a)pyrene, mg/Kg	58	2.9	450	140
Benzo(b)fluoranthene, mg/Kg	66	11.1	700	NA
Benzo(ghi)perylene, mg/Kg	ND	3.9	74	NA
Benzo(k)fluoranthene, mg/Kg	ND	13.7	0.58	34
Bis(2-chloroethyl)ether, mg/Kg	270	3040	NA	3900 (pits); 380,000 (NAPL)
Bis(2-ethylhexyl)phthalate, mg/Kg	2900	1.13	45	< 500
Butyl benzyl phthalate, mg/Kg	344	NA	NA	NA
Carbazole, mg/Kg	21.2	NA	NA	NA
Chlorophenol, 2-, mg/Kg	21.8	NA	NA	NA
Chrysene, mg/Kg	170	84.5	790	490
Cresol, o- (2-methylphenol), mg/Kg	338	NA	NA	NA
Cresol, m&p- (3&4-methylphenol), mg/Kg	472	NA	NA	NA
Dibenz(a,h)anthracene, mg/Kg	ND	5.08	NA	25
Dibenzofuran, mg/Kg	233	NA	455	NA

Table 1 Comparison of Source Characteristics and Maximum Concentrations

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Dichlorobenzene, 1,2-, mg/Kg	1400	115	NA	NA
Dichlorobenzene, 1,3-, mg/Kg	53	546	NA	NA
Dichlorobenzene, 1,4-, mg/Kg	250	194	NA	NA
Dichlorobenzidine, 3,3'-, mg/Kg	600	NA	NA	NA
Dichlorophenol, 2,4-, mg/Kg	1700	NA	NA	NA
Di-n-butyl phthalate, mg/Kg	290	NA	95	NA
Di-n-octyl phthalate, mg/Kg	380	5.1	16	NA
Diethyl phthalate	244	NA	NA	NA
Dimethylphenol, 2,4-, mg/Kg	240	NA	83	NA
Dimethylphthalate, mg/Kg	110	NA	NA	NA
Dinitrotoluene, 2,4-, mg/Kg	414	NA	NA	NA
Dinitrotoluene, 2,6-, mg/Kg	150	NA	1430	NA
Dinitro-2-methylphenol, 4,6-, mg/Kg	12,600	NA	NA	NA
Fluoranthene, mg/Kg	580	206.1	3000	960
Fluorene, mg/Kg	920	184	5400	5000
Hexachlorobenzene, mg/Kg	1800	674	NA	NA
Hexachlorobutadiene, mg/Kg	20,000	NA	NA	NA
Isophorone, mg/Kg	610	NA	NA	NA
Indeno(1,2,3-cd)pyrene, mg/Kg	ND	2.13	110	13
Methylnaphthalene, 2-, mg/Kg	12,000	NA	1600	NA
Naphthalene, mg/Kg	7630	1240	8700	36,000
Naphthylamine, 1-, mg/Kg	220	NA	NA	NA
Nitrobenzene, mg/Kg	74	NA	NA	NA
Nitrophenol, 2-, mg/Kg	1.9	NA	NA	NA
Nitrophenol, 4-, mg/Kg	1400	NA	NA	NA
Nitrosodi-n-butylamine, mg/Kg	370	NA	NA	NA
n-Nitrosodiphenylamine, mg/Kg	71.9	7	700	4700
Pentachlorobenzene	120	NA	NA	NA
Pentachlorophenol, mg/Kg	480	NA	740	670

Table 1 Comparison of Source Characteristics and Maximum Concentrations

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Phenanthrene, mg/Kg	2500	3440	8300	10,000
Phenol, mg/Kg	2200	NA	170	NA
Pyrene, mg/Kg	540	762	2500	2300
Tetrachlorobenzene, 1,2,4,5-, mg/Kg	73	NA	NA	NA
Tetrachlorophenol, 2,3,4,6-, mg/Kg	280	NA	NA	NA
Trichlorobenzene, 1,2,4-, mg/Kg	1700	NA	NA	NA
Trichlorophenol, 2,4,6-, mg/Kg	130	NA	NA	NA
Antimony, mg/Kg	617	NA	NA	3.1
Arsenic, mg/Kg	573	NA	9.9	30
Barium, mg/Kg	1.73	NA	ND	200
Beryllium, mg/Kg	8.1	NA	51.6	ND
Cadmium, mg/Kg	547	NA	7.7	920
Chromium, mg/Kg	12,000	94.4	486	550
Cobalt, mg/Kg	ND	NA	11.1	9.5
Copper, mg/Kg	10,700	1763	254	45,000
Lead, mg/Kg	83,400	NA	120	46,000
Manganese, mg/Kg	ND	NA	375	85
Mercury, mg/Kg	46.4	NA	7	4.8
Nickel, mg/Kg	1140	NA	592	160
Selenium, mg/Kg	400	NA	2	NA
Silver, mg/Kg	117	NA	7.75	ND
Thallium, mg/Kg	6.5	NA	NA	ND
Vanadium, mg/Kg	ND	NA	75	22
Zinc, mg/Kg	97,400	NA	8350	750

a – Sludge Pit

b – Oil Pit and Sludge Pit

NA – Not available in documents reviewed by URS

Table 2 Comparison of Maximum Concentrations in Groundwater (mg/L)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Total Dissolved Solids (TDS)	1624 - 20026	NA	NA	10,100 – 22,300
Acetone	2190	NA	NA	5.2
Benzene	48.2	0.778	2.53	40.45
Butanone, 2- (MEK)	84.7	NA	NA	NA
Carbon disulfide	14.1	NA	NA	NA
Carbon tetrachloride	31.7	NA	0.044	NA
Chlorobenzene	1.81	4.12	0.007	0.023
Chloroethane	0.058	NA	0.045	0.01
Chloroform	4.99	11.5	18	0.42
Dichloroethane, 1,1-	10.8	743	0.919	0.270
Dichloroethane, 1,2-	483	3580	21.2	135.6
Dichloroethene, 1,1-	5.2	NA	NA	1.70
Dichloroethene (Total), 1,2-	5.8	134	NA	NA
Dichloroethene, cis-1,2-	1.8	NA	NA	NA
Dichloroethene, trans-1,2-	0.37	124	5.87	1.255
Ethylbenzene	35.1	3.18	0.37	3.0
Hexanone, 2-	14.9	NA	NA	NA
Methyl-2-pentanone, 4- (MIBK)	61.2	NA	NA	NA
Methylene chloride	38.6	110	1.46	0.900
Styrene	8.27	NA	NA	2.2
Tetrachloroethane, 1,1,1,2-	9.62	NA	NA	NA
Tetrachloroethane, 1,1,2,2-	14.2	4.98	NA	0.291
Tetrachloroethene	54.3	2.19	1.64	0.068
Toluene	21.5	0.971	0.294	10.15
Trichloroethane, 1,1,1-	7.22	3.18	NA	NA
Trichloroethane, 1,1,2-	84	2170	NA	10.55
Trichloroethene	23.6	11.3	0.741	0.120
Vinyl chloride	2663	1080	3.2	23.9
Xylene, total	411	NA	NA	0.88

Table 2 Comparison of Maximum Concentrations in Groundwater (mg/L)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Acenaphthene	0.001	NA	NA	0.054
Acenaphthylene	ND	NA	NA	0.65
Anthracene	ND	NA	NA	0.058
Bis(2-chloroethyl)ether	2.0	38	NA	3300
Bis(2-chloroisopropyl)ether	1.6	NA	NA	33.0
Bis(2-ethylhexyl)phthalate	0.080	NA	0.071	0.106
Chlorophenol, 2-	0.060	NA	NA	NA
Cresol, o- (2-Methylphenol)	2.2	NA	NA	NA
Cresol, m&p- (3&4-Methylphenol)	5.3	NA	NA	NA
Dichlorophenol, 2,4-	3.5	NA	NA	0.04
Dimethylphenol, 2,4-	0.24	NA	NA	NA
Dimethylphthalate	0.25	NA	NA	NA
Dinitrophenol, 2,4-	0.033	NA	NA	NA
Dinitrotoluene, 2,4-	0.042	NA	NA	NA
Dinitrotoluene, 2,6-	0.038	NA	NA	NA
Hexachloroethane	0.020	NA	NA	0.04
Isophorone	0.700	NA	NA	0.02
Methylnaphthalene, 2-	ND	NA	NA	0.84
Naphthalene	0.220	NA	0.196	10
Nitrophenol, 4-	0.084	NA	NA	0.052
Phenol	40	NA	0.406	0.08
Antimony	0.01	NA	NA	< 0.02
Arsenic	75	0.110	0.006	0.044
Barium	8.61	NA	0.769	0.31
Beryllium	0.02	NA	NA	< 0.02
Cadmium	0.005	NA	0.001	0.06
Chromium	0.87	0.2	0.05	0.048
Cobalt	0.16	NA	NA	0.29
Copper	0.16	110	0.03	0.06

Table 2 Comparison of Maximum Concentrations in Groundwater (mg/L)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Lead	0.1	0.1	0.006	1.4
Manganese	38.2	NA	NA	13.9
Mercury	0.01	0.005	0.0003	< 0.001
Nickel	3.82	NA	NA	0.31
Selenium	0.012	NA	NA	0.045
Thallium	0.004	NA	NA	0.02
Vanadium	2.64	NA	NA	0.02
Zinc	0.85	NA	0.05	0.14
NA – Not available in documents reviewed by URS				

Table 3 Comparison of Maximum Concentrations in Soils and Sediments (mg/Kg)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Acetone	6	NA	NA	NA
Benzene	0.3	NA	14	7.4
Butanone, 2- (MEK)	3	NA	NA	NA
Carbon disulfide	0.023	NA	NA	NA
Chlorobenzene	ND	1.78	NA	1.1
Chloroform	ND	2.6	ND	< 0.01
Dichloroethane, 1,1-	ND	1.51	2.6	0.012
Dichloroethane, 1,2-	ND	515	5.3	84
Dichloroethene, 1,1-	1	46	NA	3.1
Dichloroethene, trans-1,2-	ND	1.08	2.1	3.7
Ethylbenzene	6	146	14.9	50.2
Methylene chloride	5	57.7	ND	1
Styrene	2	0.05	NA	60
Tetrachloroethene	0.003	1.33	ND	0.7
Tetrachloroethane, 1,1,2,2-	ND	1.2	NA	5.8
Toluene	46	6.78	11.9	10
Trichloroethane, 1,1,1-	158	ND	ND	NA
Trichloroethane, 1,1,2-	ND	918	NA	191
Trichloroethene	1400	2.09	ND	2.6
Vinyl chloride	ND	0.04	ND	1.2
Xylenes, total	14	NA	NA	7.5
PCB (Total)	0.19(Sed) ND (Soil)	NA	24 (Sed) 237 (soil)	NA
Acenaphthene	67	8	68	24
Acenaphthylene	8	NA	280	77
Anthracene	41	ND	16	140
Benzo(a)anthracene	33	7	55	6.5
Benzo(a)pyrene	0.94	NA	ND	4.5

Table 3 Comparison of Maximum Concentrations in Soils and Sediments (mg/Kg)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Benzo(b)fluoranthene	0.8	9	32	3.4
Benzo(ghi)perylene	0.36	NA	ND	NA
Benzo(k)fluoranthene	0.84	15	NA	< 0.2
Bis(2-chloroethyl)ether	ND	NA	NA	610
Bis(2-chloroisopropyl)ether	ND	NA	NA	309
Bis(2-ethylhexyl)phthalate	190	NA	17	NA
Butyl benzyl phthalate	63	NA	NA	NA
Chrysene	1.1	21	30.1	6.4
Dibenz(a,h)anthracene	0.26	NA	NA	NA
Dibenzofuran	0.066	NA	NA	NA
Dichlorobenzene, 1,3-	1.5	NA	NA	NA
Dichlorobenzene, 1,4-	0.12	NA	NA	NA
Diethyl phthalate	0.055	NA	NA	NA
Di-n-butyl phthalate	20	NA	0.18	NA
Di-n-octyl phthalate	49	NA	15	NA
Fluoranthene	300	998	173.7	17
Fluorene	37	13	171	54
Hexachlorobenzene	0.48	NA	NA	NA
Hexachlorobutadiene	3	NA	NA	NA
Indeno(1,2,3-cd)pyrene	0.57	NA	NA	NA
Methylnaphthalene, 2-	7	NA	NA	24
Naphthalene	11	11	480	213
Phenanthrene	120	212	481.6	160
Phenol	6	NA	0.2	NA
Pyrene	250	30	259.3	37
Trichlorobenzene, 1,2,4-	0.13	NA	NA	NA
Antimony	20.5 (Sed) ND (Soil)	NA	NA	< 2
Arsenic	29.2 (Sed)	NA	1.4 (Sed)	1.9

Table 3 Comparison of Maximum Concentrations in Soils and Sediments (mg/Kg)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
	3.4 (Soil)		2.4 (Soil)	
Barium	267 (Sed) 3550 (Soil)	NA	NA	790
Beryllium	1.3 (Sed) 0.4 (Soil)	NA	7.3 (Sed) 0.5 (Soil)	4.2
Cadmium	2.3 (Sed) 1.2 (Soil)	NA	0.2 (Sed) 0.5 (Soil)	9
Chromium	79.2 (Sed) 92 (Soil)	35	48	18
Cobalt	10.9 (Sed) 2.3 (Soil)	NA	NA	15
Copper	105 (Sed) 4.2 (Soil)	424	5.0 (Sed) 96 (Soil)	4600
Lead	232 (Sed) 49 (Soil)	NA	21.5 (Sed) 136 (Soil)	50
Manganese	351 (Sed) 131 (Soil)	NA	NA	3100
Mercury	0.25 (Sed) ND (Soil)	NA	0.26 (Sed) 1.6 (Soil)	< 0.02
Nickel	15.9 (Sed) 4 (Soil)	NA	10.0 (Sed) 12.0 (Soil)	62
Selenium	1.4 (Sed) ND (Soil)	NA	ND (Sed) 0.7 (Soil)	< 0.2
Silver	3.5 (Sed) ND (Soil)	NA	0.02 (Sed) 0.1 (Soil)	< 1
Thallium	1.9 (Sed) ND (Soil)	NA	NA	< 1
Tin	11 (Sed) ND (Soil)	NA	NA	15
Vanadium	29.9 (Sed) 14.5 (Soil)	NA	NA	24

Table 3 Comparison of Maximum Concentrations in Soils and Sediments (mg/Kg)

Parameter	Malone URS 2004	Brio IT 1987	French REI 1986	MOTCO B&V 1982; WCC 1984
Zinc	323 (Sed) 21.2 (Soil)	NA	68 (Sed) 122 (Soil)	380
NA – Not available in documents reviewed by URS Sed - Sediment				

Table 4 Remedial Alternatives Evaluated at Example Sites - Groundwater

Site/Technology	Pump and Treat	Monitored Natural Attenuation	Vertical Barrier Wall	Deep Well Disposal	Bioremediation	Other
Bailey Waste Disposal		√				Not Potable Water
Brio Refining, Inc			√			
Dixie Oil Processors						Active groundwater treatment not warranted
Dutchtown Treatment Plant	•	√		•	•	
French, LTD	√ (outside wall)		√ (sheet pile wall)			
Gulf Coast Vacuum Services	•	√				
Highlands Acid Pit	•	√	•	•		
Mallard Bay Landing						Source Control
MOTCO, Inc	√	•	√			
Old Inger Oil Refinery	√			•		
PAB Oil & Chemical Service		√				Active groundwater treatment not warranted
Petro-Chemical Systems, Inc (Turtle Bayou)	•				√	Solvent Extraction; steam stripping
Petro-Processors of Louisiana, Inc	√	√				Thermal extraction
Sheridan Disposal Services	•	√	•			
Sikes Disposal Pits		√	•			

● Evaluated and Not Chosen

√ Evaluated and Chosen

Table 5 Remedial Alternatives Evaluated and Not Chosen at Example Sites – Sludge/Soil

Site/Technology	Bioremediation	Cap	Incineration (off-site)	Incineration (on-site)	Landfill (off-site)	Landfill (on-site)	Solidification / Stabilization	Other
Bailey Waste Disposal				●	●	●		
Brio Refining, Inc	●			●	●		●	
Dixie Oil Processors	●	●		●	●		●	
Dutchtown Treatment Plant								
French, LTD				●			●	Vertical Barrier Wall
Gulf Coast Vacuum Services			●	●			● (Sludge)	
Highlands Acid Pit		●				●		Waste Encapsulation
Mallard Bay Landing			●					Low Temperature Thermal Desorption
MOTCO, Inc	●		●	●		●		
Old Inger Oil Refinery						●	●	
PAB Oil & Chemical Service	●		●	●				
Petro-Chemical Systems, Inc (Turtle Bayou)					●			Thermal destruction
Petro-Processors of Louisiana, Inc	●		●		●	●	●	In-situ soil flushing; Solvent extraction
Sheridan Disposal Services	●		●					Solvent extraction
Sikes Disposal Pits	●		●		●	●		

Table 6 Remedial Alternatives Chosen at Example Sites – Sludge/Soil

Site/Technology	Bioremediation	Cap	Incineration (off-site)	Incineration (on-	Landfill (off-site)	Landfill (on-site)	Solidification / Stabilization	Other
Bailey Waste Disposal		√ (after AMD)			√ (Marsh Sediment)		√ (removed in AMD)	Sediment –excavate to waste channel
Brio Refining, Inc		√ (Soil)						
Dixie Oil Processors								Limited Action
Dutchtown Treatment Plant			√ (Sludge)				√ (Soil)	Soil washing prior to stabilization
French, LTD	√							
Gulf Coast Vacuum Services	√ (Sludge)						√ (soil)	
Highlands Acid Pit					√			
Mallard Bay Landing							√ (Soil)	Thermal desorption (sludge)
MOTCO, Inc			√ (Sludge)				√ (Soil)	Cap Final remedy
Old Inger Oil Refinery	√	√						
PAB Oil & Chemical Service							√	
Petro-Chemical Systems, Inc (Turtle Bayou)	√					√		Soil Vapor Extraction; Thermal Desorption
Petro-Processors of Louisiana, Inc		√						
Sheridan Disposal Services							√	
Sikes Disposal Pits				√				

Table 7 Media Objectives and Response Actions for the Brio Refining Superfund Site

Media	Objective	Response Action
Groundwater	1. Achieve target NUMEROUS SAND CHANNEL ZONE groundwater concentrations to protect aquatic life in Mud Gully. 2. Achieve target levels of organic constituents in the Fifty-Foot Sand within a reasonable time.	1. Natural Attenuation/ Monitoring 2. Pumping 3. Aqueous and Liquid Waste Treatment
Sludge and wastes	Control off-site migration of pit residues.	1. Natural Attenuation/ Monitoring 2. Gas Recovery and Treatment 3. Solidification/ Stabilization 4. Capping 5. Soil Washing 6. Solid and liquid-phase biodegradation 7. Rotary Kiln and infrared incineration 8. Landfills and temporary storage
Soils	1. Control off-site transport of affected soils. 2. Achieve target soil concentration levels to assure a 1 x 10^{-6} risk level for public exposure to air emissions. 3. Achieve target soil concentration levels to assure a 1 x 10^{-6} risk level for affected soil dermal contact and ingestion.	
Air	None stated in FS; however, remedial alternatives designed to minimize exposure to site workers and nearby residents.	1. Natural Attenuation/ Monitoring 2. Dust Control 3. Capping 4. Gas Recovery and Treatment 5. In-situ treatment

Table 8 Remedial Alternatives Evaluated in Initial Screening for the Brio Refining Superfund Site

Remedial Alternative	Technical Feasibility	Environmental Effectiveness
No Action	Superior – Easily implemented with no design or constructability problems.	Unacceptable – Could result in future release to the environment.
Cap and Cover with Soil Venting	Acceptable – Demonstrated technology for isolating affected materials, reducing leachate formation, and collecting vapors. Long-term integrity is uncertain.	Acceptable – Achieves remedial objectives, reduces mobility of affected materials.
Stabilization and placement in Vault	Acceptable – Demonstrated technology for containing affected materials. Long-term integrity is uncertain.	Acceptable – Achieves remedial objectives, reduces mobility of affected materials.
Biological Treatment	Superior – Site- specific demonstration of solid-phase biodegradation process. Liquid-phase process proven at other sites for similarly affected materials.	Superior – Exceeds remedial objectives, achieves significant reduction in mobility, toxicity, and volume of affected materials.
Incineration	Superior – Site-specific demonstration of infrared incinerator.	Superior – Exceeds remedial objectives, achieves significant reduction in mobility, toxicity, and volume of affected materials.
Off-site disposal	Unacceptable – Lack of disposal capacity precludes implementation of this plan.	Unacceptable – Potential for transportation accidents.
All alternatives include recovery and treatment of Numerous Sand Channel Zone (NSCZ) groundwater; recovery and off-site disposal of DNAPL; and natural attenuation of Fifty-Foot Sand.		

Table 9 Advantages and Disadvantages from Detailed Evaluation of Remedial Alternatives for the Brio Refining Superfund Site

Remedial Alternative	Advantages	Disadvantages
Cap and Cover with Soil Venting	1. Construction requirements for cap and cover are proven, practical and standardized. 2. Stabilization of affected soils is a proven technique. 3. Soil venting study showed process capable of significant reductions in fugitive VOC emissions. 4. Alternative could be implemented in approximately four years.	1. Does not reduce volume of contaminants. 2. Low gas flows generated during treatability experiments. 3. VOC reductions were not sufficient to consider venting a primary treatment. 4. Fugitive emissions from stabilization require construction of temporary enclosures equipped with a portable fume incinerator for destruction of VOCs. 5. Predicted well yields in NSCZ of 1 gpm due to low transmissivity. 6. Post-closure care of cap.
Stabilization and Placement in Vault	1. Construction requirements for cap and cover are proven, practical and standardized. 2. Liner and leachate system provides cost-effective isolation of materials placed in vault. 3. Stabilization of affected soils is a proven technique. 4. Soil venting study showed process capable of significant reductions in fugitive VOC emissions. 5. Alternative could be implemented in approximately four years.	1. Does not reduce volume of contaminants. 2. Construction requirements are more stringent for vault than cap and cover. 3. Construction of vault would require stockpiling of materials from six pits in an enclosed, lined staging area. 4. Low gas flows generated during treatability experiments. 5. VOC reductions were not sufficient to consider venting a primary treatment. 6. Fugitive emissions from stabilization required construction of temporary enclosures equipped with a portable fume incinerator for destruction of VOCs. 7. Predicted well yields in NSCZ of 1 gpm due to low transmissivity.

Table 9 Advantages and Disadvantages from Detailed Evaluation of Remedial Alternatives for the Brio Refining Superfund Site

Remedial Alternative	Advantages	Disadvantages
		8. Post closure care of vault cap and additional O&M for maintaining liner and leachate system.
Biological Treatment	1. Achieves reductions in volume, toxicity, and mobility of organic contaminants reducing future O&M costs. 2. Pilot study of solid phase biological treatment provided significant reductions in both VOC and PAH concentrations. 3. Aqueous-phase system was based on wastewater biological treatment systems. 4. Solid-phase system was based on treatment of refinery sludge. 5. Estimated aqueous-phase treatment would require 3 years to complete.	1. Fugitive emissions from pit excavation require construction of temporary enclosures equipped with a portable fume incinerator for destruction of VOCs. 2. Approximately 104 days of solid-phase treatment were required to treat 200 yd^3 of material in one enclosure. Estimated solid-phase treatment would require 9 years to complete.
Incineration	1. Incineration is successfully used to detoxify/destroy liquid and solid hazardous wastes. 2. Pilot studies demonstrated that an infrared incinerator was capable of thermally destroying site contaminants. 3. Treatment would require one to three years depending on combustion technology.	1. Fugitive emissions from pit excavation require construction of temporary enclosures equipped with a portable fume incinerator for destruction of VOCs.
All alternatives include recovery and treatment of Numerous Sand Channel Zone (NSCZ) groundwater; recovery and off-site disposal of DNAPL; and natural attenuation of Fifty-Foot Sand.		

Table 10 Cost Estimates for Remedial Alternatives for Brio Refining Superfund Site

Remedial Alternative	Total Present Worth in 1988 ($M)	Total Present Worth in 2004 ($M)	Estimated Cubic Yards	2004 $/cubic yard
Cap and Cover with Soil Venting	13.5	21.9	63,000	350
Stabilization and placement in Vault	20.9	34.0	63,000	540
Biological Treatment	23.0	37.4	63,000	590
Incineration	22.3	36.2	63,000	575

USEPA 1988b

Note: cost estimates are based on volumes and costs presented in the ROD (USEPA 1988b); not on actual volumes remediated or costs incurred.

Table 11 Media Objectives and Response Actions for the French Limited Superfund Site

Media	Objective	Response Action
Groundwater	1. Minimize contamination in the Upper Aquifer.	1. Restore Upper Aquifer.
Surface water	1. Prevent human contact with contaminated surface water. 2. Minimize contamination in the Upper Aquifer.	1. Treat or dispose of surface water
Sludge and wastes	1. Minimize health hazards associated with direct contact of contaminated sludge/wastes. 2. Minimize contamination in the Upper Aquifer. 3. Minimize impact of contaminated runoff. 4. Minimize migration of waste during flood events.	1. Isolate and/or cap all sludge/wastes 2. Remove and dispose of all sludge/wastes 3. Treat sludge/wastes
Soils	1. Minimize health hazards associated with direct contact of contaminated soils. 2. Minimize contamination in the Upper Aquifer. 3. Minimize impact of contaminated runoff.	1. Isolate and cap all contaminated soils. 2. Remove and dispose of all contaminated soils. 3. Treat contaminated soils. 4. Water flush contaminated soils.
Air	Minimize the potential of any adverse air discharges	Only applies to remedial technologies.

Table 12 Remedial Alternatives Evaluated in Initial Screening for the French Limited Superfund Site

Remedial Alternative	Treat/ Discharge Surface Water	Incineration	Biological Treatment	Chemical Fixation Residues	Other
1	√	√ [a]		√	
2	√	√ [b]		√	Thermally strip soils
3	√	√ [b]		√ [c]	
4	√	√ [b]	√ [c]	√ [c]	
5	√	√ [b]			Water leach soils and ash
6	√		√ [a]	√	
7	√		√ [b]	√	
8	√		√ [b]		Water leach soils and ash
9	√	√ [a]		√	
10				√ [b]	Slurry wall and cap
11					No Action

[a] – Soils and sludge

[b] – Sludge

[c] – Soils

All alternatives allow Upper Aquifer to restore naturally.

Table 13 Advantages and Disadvantages from Detailed Evaluation of Remedial Alternatives for the French Limited Superfund Site

Remedial Alternative	Advantages	Disadvantages
1 (On-site incineration of soils and sludge)	1. Removal of contamination above ROD cleanup levels. 2. Incineration is successfully used to detoxify/destroy liquid and solid hazardous wastes. 3. Chemical fixation is successfully used on inorganic wastes. 4. Sheet piling to isolate surface water from groundwater during dewatering and excavation. 5. Dike to protect site from flooding. 6. Approximately 4 years to complete remediate sludge and soils. 7. After source removal, groundwater quality was predicted to reach the 10^{-4} to 10^{-7} range within 30 years.	1. Generation of volatile and particulate emissions exceeding health based standards. 2. Structural stability of sludge and soils for support of earth-moving equipment. 3. Incineration of soils would require blending with a higher BTU waste or larger volume of supplemental fuel. 4. Incinerated soils produce a large volume of fine ash that can accumulate between the primary and secondary chambers reducing incinerator capacity. 5. Presence of silts and other sediment material in sludge will also contribute to ash problems. 6. Scrubbing of chlorides and sulfur required to meet RCRA requirements. 7. Production of approximately 110,200 yd^3 of ash with heavy metals in significant concentrations. 8. Size of site did not permit total excavation of backfilled materials prior to incineration. 9. Additional soils will be required to complete backfilling and surface restoration.
3 (On-site incineration of sludge and chemical fixation of soils)	1. Removal of contamination above ROD cleanup levels. 2. Incineration is successfully used to detoxify/destroy liquid and solid hazardous wastes. 3. Chemical fixation is successfully used on inorganic wastes with less than 2% organic content. Contaminated soils contained less than 1% organic material. 4. Sheet piling to isolate surface water	1. Generation of volatile and particulate emissions exceeding health based standards. 2. Structural stability of sludge and soils for support of earth-moving equipment. 3. Presence of silts and other sediment material in sludge will also contribute to ashing. 4. Scrubbing of chlorides and sulfur required to meet RCRA requirements. 5. Production of approximately 25,700 yd^3 of ash with heavy metals in significant concentrations. 6. Size of site did not permit total excavation of

Table 13 Advantages and Disadvantages from Detailed Evaluation of Remedial Alternatives for the French Limited Superfund Site

Remedial Alternative	Advantages	Disadvantages
	from groundwater during dewatering and excavation. 5. Dike to protect site from flooding. 6. Approximately 3 years to complete remediate sludge and soils. 7. After source removal, groundwater quality was predicted to reach the 10^{-4} to 10^{-7} range within 30 years.	backfilled materials prior to incineration. 7. Additional soils will be required to complete backfilling and surface restoration.
10 (Isolate sludge and soils with slurry wall and cap)	1. Hydraulic isolation of the main waste pit from the groundwater would reduce migration of hazardous contaminants into the Upper Aquifer. 2. Stabilization of sludge, placement inside slurry wall and construction of multi-layer cap over stabilized materials. 3. Low groundwater flow velocity would allow groundwater to move around the sides of the slurry wall through the southern boundary of the site.	1. Did not comply with RCRA or TSCA guidance. 2. Construction of 4,300 linear feet of 3-foot thick soil-bentonite or cement-bentonite slurry wall. 3. Stabilization of sludge would generate volatile organic and particulate emissions above health-based standards. 4. Stabilization admixture would increase in-situ volume by 85 percent. 5. Concentrated organic leachate within the capped cell could affect the integrity of the slurry wall barrier. 6. Periodically groundwater and leachate accumulating within cell would be pumped out to maintain negative head pressure. 7. Pumped groundwater would require treatment prior to discharge. 8. Long-term O&M of cap.
11 (No action)	1. No disruptions to area.	1. Allowed continued migration of contaminants to Upper Aquifer. 2. Potential for human contact with contaminated sludge, liquids and soils. 3. Potential for exposing surrounding residents to site contaminants.

Table 14 Cost Estimates for Remedial Alternatives for the French Limited Superfund Site

Remedial Alternative	Total Present Worth in 1987 ($M)	Total Present Worth in 2004 ($M)	Estimated Cubic Yards	2004 $/cubic yard
1 (On-site incineration of sludge and soils) [a]	124.8	211.0	76,000	2780
3 (On-site incineration of sludge and chemical fixation of soils) [a]	75.5	127.6	76,000	1680
10 (Isolate sludge and soils with slurry wall and cap) [a]	44.4	75.1	76,000	990
11 (No action) [a]	0.5	0.84	NA	NA
In-situ biological [b]	49	79.5	76,000	1050

NA – Not Applicable;

[a] Costs for alternatives 1, 3, 10 and 11 based on evaluation in Feasibility Study (TWC 1987) and not on actual volumes remediated. Costs include $4.2M for dike construction and $2.1M for on-site laboratory.

[b] - Costs for the in-situ biological treatment are categorized as pre-treatment (34%), treatment (55%) and post-treatment (11%). Costs include development and pilot scale studies, flood wall construction, operation and maintenance, analytical, dewatering, fixation, technical support and administration, demobilization and EPA oversight (USEPA 1995).

Table 15 Media Objectives for the MOTCO Superfund Site

Media	Objective
Groundwater	1. Manage migration of contaminants through transmissive zone horizontally to nearby surface water. 2. Manage migration of contaminants vertically to the underlying Upper Chicot. 3. Manage migration of contaminants from UC-3 horizontally to nearby drinking water well. 4. Manage migration of contaminants from transmissive zone to process wells downgradient of the site. 5. Manage migration of contaminants into surface water.
Surface water	Manage migration of contaminants into nearby marsh.
Sludge and wastes	1. Prevent further contamination of the shallow aquifer and eliminate potential threat to nearby surface water from the pit wastes. 2. Eliminate the threat to public health from potential air releases and runoff from the pit wastes. 3. Mitigate the potential for release due to tidal flood surges for wastes remaining on-site, if any.
Soils	1. Manage direct contact and ingestion exposure to surface soils. 2. Manage migration of contaminants vertically and laterally through soils to groundwater.
Air	Control and minimize air quality impacts, during and after remedial actions, from release of hazardous volatiles.
USEPA 1985; USEPA 1989	

Table 16 Remedial Alternatives Evaluated in Initial Screening for the MOTCO Superfund Site

Remedial Alternative	Source Control		Management of Migration
	Incineration	Landfill	
1	No Action		No Action
2	Offsite	Offsite	Institutional Controls
3	Offsite TSCA/RCRA		Slurry wall containment; pump and treat groundwater; soil excavation, consolidation and capping
4	TSCA only		Pump and treat groundwater; soil excavation, consolidation and capping
5	Offsite	Onsite RCRA	Pump and treat groundwater; soil excavation, on-site incineration
6	Offsite		Pump and treat groundwater; soil excavation, on-site bioremediation
7		Onsite soils only	
8		Onsite soils, sludge, tars	
9	Onsite liquids		
10	Onsite rotary kiln		
11	Onsite	Onsite RCRA	

USEPA 1985; USEPA 1989

Note: Source control remedial alternatives are independent of management of migration remedial alternatives.

Table 17 Advantages and Disadvantages from Detailed Evaluation of Remedial Alternatives for the Source Control Operable Unit at the MOTCO Superfund Site

Remedial Alternative	Advantages	Disadvantages
2 (Offsite incineration/ off-site landfill)	1. Least cost for disposal of organic liquids by incineration. 2. Minimal on-site facility construction. 3. No long-term operation, maintenance or monitoring required. 4. All waste media are removed from site and the most hazardous (organic liquids) are destroyed. 5. Commercial waste incineration capacity not consumed.	1. TSCA permits and applicable state permits required and trial burn possibly required. 2. Schedule limited to capacity of industrial incinerators. 3. Risk of exposure during transport to hazardous volatiles and sludge/tars. 4. Treatment of pit surface water would require treatability study, revision of GCWDA permit, and access agreements and easements for pipeline to GCWDA. 5. Risk of exposure to volatiles in sludge/tars during solidification. 6. Technical uncertainty for solidification of sludge/tars.
3 (Commercial PCB/ Industrial Non-PCB Incineration)	1. Least cost for disposal of organic liquids by incineration. 2. Minimal on-site facility construction. 3. No long-term operation, maintenance or monitoring required. 4. All waste media are removed from site and the most hazardous (organic liquids) are destroyed. 5. No additional permits or approvals are needed. 6. Commercial incineration of PCB-containing wastes is well documented.	1. Costs of PCB-approved incineration considerably higher than industrial incineration. 2. Consumes commercial incineration capacity and schedule limited to capacity of PCB-approved incinerators. 3. Risk of exposure during transport to hazardous volatiles and sludge/tars. 4. Treatment of pit surface water would require treatability study, revision of GCWDA permit, and access agreements and easements for pipeline to GCWDA.
10 (Onsite Rotary Kiln Incineration)	1. No transport of organic liquids, sludge, tars and other solids. 2. Wastes are thermally destroyed, eliminating long term risks. 3. Rotary kiln incineration and liquid injection incineration reasonably proven	1. Extensive on-site construction required. 2. Highly acidic scrubber water generated. 3. Time of implementation constrained by construction and operation schedule. 4. Air emissions.

Table 17 Advantages and Disadvantages from Detailed Evaluation of Remedial Alternatives for the Source Control Operable Unit at the MOTCO Superfund Site

Remedial Alternative	Advantages	Disadvantages
	technologies. 4. Technical and cost uncertainties with solidification of sludge/tars eliminated. 5. Pit surface water could be directly discharged after pretreatment or flexibility of treatment at GCWDA. 6. Minimal ash generation. 7. No consumption of commercial incineration capacity.	5. Federal incineration permit technical standards must be met; state permits may be required.
11 (Onsite incineration/ on-site landfill)	1. No transport of organic liquids, sludge, tars and other solids. 2. Wastes are thermally destroyed, eliminating long term risks. 3. Rotary kiln incineration reasonably proven technologies. 4. Technical and cost uncertainties with solidification of sludge/tars eliminated. 5. Pit surface water could be directly discharged after pretreatment. 6. No consumption of commercial incineration capacity. 7. Onsite incineration capacity could be based on compromise between costs and schedule.	1. Maximum on-site construction required. 2. Contaminated soils remain in on-site landfill requiring long-term operation, maintenance, and monitoring. 3. Some long-term risk of release to groundwater. 4. Highly acidic scrubber water generated. 5. Time of implementation constrained by construction and operation schedule. 6. Air emissions. 7. Federal incineration permit technical standards must be met; state permits may be required. 8. Incinerator ash is generated and may require solidification and disposal in a secure landfill

Table 18 Cost Estimates for Source Control Remedial Alternatives for the MOTCO Superfund Site

Remedial Alternative	Total Present Worth in 1984 ($M)	Total Present Worth in 2004 ($M)	Estimated Cubic Yards	2004 $/ Cubic Yards
2 (Offsite incineration/ off-site landfill)	34.5	61.8	59,100	1050
3 (Commercial PCB/ Industrial Non-PCB Incineration)	42.3	75.7	59,100	1280
10 (Onsite Rotary Kiln Incineration)	48.9	87.6	59,100	1480
11 (Onsite incineration/ on-site landfill)	47.2	84.5	59,100	1430

USEPA 1985

Note: cost estimates are based on volumes and costs presented in the ROD (USEPA 1985); not on actual volumes remediated nor actual costs incurred.

Table 19 Cost Estimates for the Management of Migration Remedial Alternatives for the MOTCO Superfund Site

Remedial Alternative	Total Present Worth in 1989 ($M)	Total Present Worth in 2004 ($M)	Estimated Cubic Yards[a]	2004 $/cubic yard
1 (No Action)	0.077	0.117	NA	NA
2 (Institutional Controls)	3.60	5.45	82,300	66
3 (Slurry wall containment; pump and treat groundwater; soil excavation, consolidation and capping)	8.13	12.3	82,300	150
4 (Pump and treat groundwater; soil excavation, consolidation and capping)	8.81	13.3	82,300	160
5 (Pump and treat groundwater; soil excavation, on-site incineration)	13.4* 20.3**	20.3* 30.8**	82,300	250* 370**
6 (Pump and treat groundwater; soil excavation, on-site bioremediation)	17.9	27.1	82,300	330

USEPA 1989

[a] – 62,300 cubic yards of soil and sediment and approximately 20,000 cubic yards of DNAPL (approximately 4 million gallons DNAPL)

* Existing source control incinerator

** Mobile incinerator

Note: cost estimates are based on volumes and costs presented in the ROD (USEPA 1989); not on actual volumes remediated or costs incurred.

Table 20 Summary of Preliminary Action-Specific ARARs and TBCs

ARAR	Regulatory Citation	Specificity
Federal		
National Emission Standards for Hazardous Air Contaminants (NESHAP)	40 CFR 61	Air; Remedial Action
National Emission Standards for Hazardous Air Contaminants for Source Categories: Remediation	40 CFR 63.7880-63.7957	Air; Remedial Action
Oil Pollution Prevention	40 CFR 112	Water; Remedial Action
National Pollutant Discharge Elimination System (NPDES)	40 CFR 122	Water; Remedial Action
Technology-Based Treatment Requirements in Permits	40 CFR 125.3	Water; Remedial Action
Underground Injection Control Program	40 CFR 144	Water; Remedial Action
Underground Injection Control Program: Criteria and Standards	40 CFR 146	Water; Remedial Action
Hazardous Waste Injection Restrictions	40 CFR 148	Water; Remedial Action
Section 404(b)(1) Guidelines For Specification Of Disposal Sites For Dredged Or Fill Material	40 CFR 230	Ecological; Remedial Action
Hazardous Waste Management System: General	40 CFR 260	Waste; Remedial Action
Identification and Listing of Hazardous Waste	40 CFR 261	Waste; Remedial Action
Standards Applicable to Generators of Hazardous Waste	40 CFR 262 (A, B, C, D)	Waste; Remedial Action
Standards Applicable to Transporters of Hazardous Waste	40 CFR 263	Waste; Remedial Action
Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264	Waste; Remedial Action
Land Disposal Restrictions	40 CFR 268	Waste; Remedial Action
Procedures for Planning and Implementing Off-Site Response Actions	40 CFR 300.440	Waste; Remedial Action
General Pretreatment Regulations for Existing and New Sources of Pollution for Publicly Owned Treatment Works (POTW)	40 CFR 401; 40 CFR 403	TBC; Water; Remedial Action
Effluent Guidelines and Standards – Landfills Point Source Category	40 CFR 445	Water; Remedial Action
Occupational Safety and Health Standards: Toxic and Hazardous Substances	29 CFR 1910.1000	Health and Safety; Remedial Action

Table 20 Summary of Preliminary Action-Specific ARARs and TBCs

ARAR	Regulatory Citation	Specificity
Occupational Safety and Health Standards: Safety and Health Regulations for Construction	29 CFR 1910.1926	Health and Safety; Remedial Action
Department of Transportation (DOT); Hazardous Materials Regulations	49 CFR 171 - 180	TBC; Remedial Action
State of Texas		
Facilities (Emissions and Distance Limitations)	30 TAC 106.262.	Air; Remedial Action
Permits by Rule (Waste Processes and Remediation)	30 TAC 106.532 - 106.534	Air; Remedial Action
Control of Air Pollution from Volatile Organic Compounds (VOCs)	30 TAC 115	Air; Remedial Action
General Permits for Waste Discharges	30 TAC 205	Water; Remedial Action
Additional Conditions for Solid Waste Storage, Processing, or Disposal Permits	30 TAC 305.141-305.150	Waste; Remedial Action
Additional Conditions for Injection Well Permits	30 TAC 305.151-305.159	Water; Remedial Action
Permits for Land Treatment Demonstrations Using Field Tests or Laboratory Analyses	30 TAC 305.181-305.184	Waste; Remedial Action
Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)	30 TAC 308	Water; Remedial Action
Toxic Pollutant Effluent Standards	30 TAC 314	Water; Remedial Action
Pretreatment for Existing and New Sources of Pollution	30 TAC 315	Water; Remedial Action
Control of Certain Activities by Rule: Discharge to Surface Waters From Treatment of Petroleum Fuel Substance Contaminated Waters	30 TAC 321.131 - 321.138	Water; Remedial Action
Used Oil Standards	30 TAC 324	Waste; Remedial Action
Spill Prevention and Control	30 TAC 327	Water; Remedial Action
Underground Injection Control; Standards for Class I Wells Other than Salt Cavern Solid Waste Disposal Wells	30 TAC 331.61-331.68	Water; Remedial Action
Underground and Aboveground Storage Tanks	30 TAC 334	Waste; Remedial Action
Industrial Solid Waste and Municipal Hazardous Waste	30 TAC 335	Waste; Remedial Action
Texas Risk Reduction Program	30 TAC 350	Waste and Water; Remedial Action

Table 20 Summary of Preliminary Action-Specific ARARs and TBCs

ARAR	Regulatory Citation	Specificity
Other		
TexTin OU-4 Remedial Action	Not Applicable	Remedial Action
TexTin OU-4 NRD Settlement	Not Applicable	Remedial Action
CFR –Code of Federal Regulations TAC – Texas Administrative Code		

Table 21 Summary of Preliminary Chemical-Specific ARARs and TBCs

ARAR	Regulatory Citation	Specificity
Federal		
National Primary and Secondary Ambient Air Quality Standards (NAAQS)	40 CFR 50	TBC; Air; Remedial Action
Water Quality Standards	40 CFR 131	Water; Remedial Investigation
National Primary Drinking Water Regulations	40 CFR 141	Water; Remedial Investigation
Alternate Cleanup Levels	40 CFR 264.94	TBC; Waste; Remedial Action
Land Disposal Restrictions	40 CFR 268	Waste; Remedial Action
Occupational Safety and Health Standards: Toxic and Hazardous Substances	29 CFR 1910.1000	Health and Safety; Remedial Investigation and Remedial Action
Occupational Safety and Health Standards: Safety and Health Regulations for Construction	29 CFR 1910.1926	Health and Safety; Remedial Investigation and Remedial Action
USEPA Region 6 Human Health Medium-Specific Screening Levels	Not Applicable	TBC; Remedial Action
State of Texas		
Nuisance	30 TAC 101.4	Air; Remedial Action
Drinking Water Standards Governing Drinking Water Quality and Reporting Requirements for Public Water Supply Systems	30 TAC 290F	Water; Remedial Action
Texas Surface Water Quality Standards	30 TAC 307	Water Remedial Action
Criteria and Standards for the National Pollutant Discharge Elimination System (NPDES)	30 TAC 308	Water; Remedial Action
Toxic Pollutant Effluent Standards	30 TAC 314	Water; Remedial Action
Used Oil Standards	30 TAC 324	Waste; Remedial Action
Texas Risk Reduction Program	30 TAC 350	Waste and Water; Remedial Investigation and Remedial Action
CFR –Code of Federal Regulations TAC – Texas Administrative Code		

Table 22 Summary of Preliminary Location-Specific ARARs and TBCs

ARAR	Regulatory Citation	Specificity
Federal		
Statement of Procedures on Floodplain Management and Wetlands Protection	40 CFR 6, Appendix A	Ecological; Remedial Action
	Executive Order 11990	Floodplain
Floodplain Management	Executive Order 11988; 40 CFR 6 Appendix A	Floodplain
Section 404(b)(1) Guidelines For Specification Of Disposal Sites For Dredged Or Fill Material	40 CFR 230	Ecological; Remedial Action
Ocean Dumping	40 CFR 231	Ecological; Remedial Action
Location Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities	40 CFR 264.18	Remedial Action
Endangered and Threatened Wildlife and Plants	50 CFR 17	Ecological; Remedial Action
Designated Critical Habitat	50 CFR 226.101-226.214	Ecological; Remedial Action
State of Texas		
Certain Historic Cemeteries	Texas Health and Safety Code Chapter 715	Remedial Action
CFR –Code of Federal Regulations TAC – Texas Administrative Code		

FIGURES

Figure 1 Site Location Map

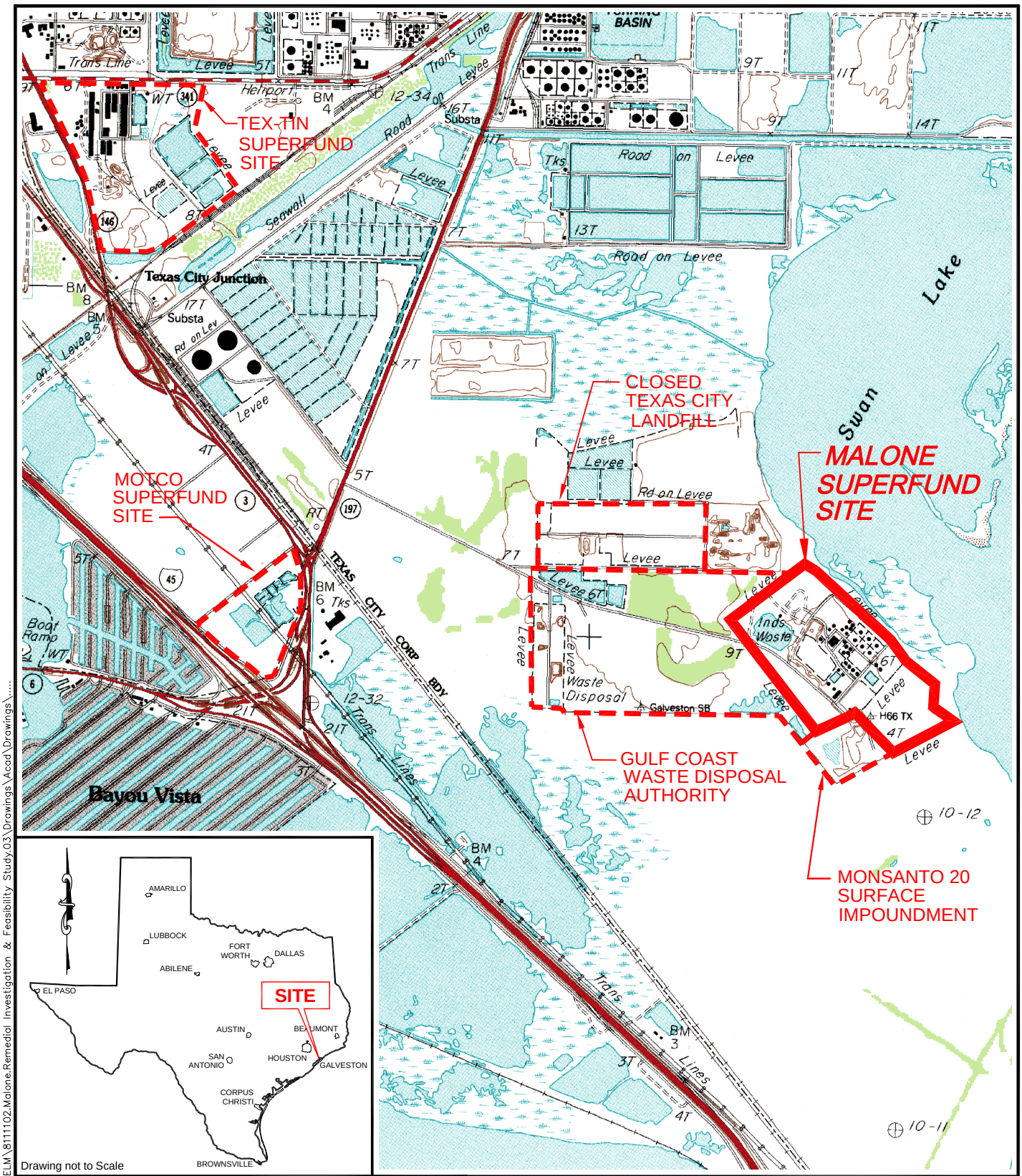
Figure 2 Site Map

Figure 3 1969 Aerial Photograph

Figure 4 Conceptual Site Model

Figure 5 Geologic Map

Figure 6 Stratigraphic and Hydrogeologic Cross-Section



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APPROXIMATE SCALE IN FEET
SCALE= 1:24000

Source:
U.S.G.S. 7.5-minute series topographic map.
Virginia Point, Texas Quadrangle.

URS
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FAX: (713) 789-8404

Scale:	Drawn by:	Date:
As Shown	SJF	2-10-04
	Chk'd by: BPB	Date: 2-10-04

Title: **SITE LOCATION MAP**

Project: **MALONE SERVICE CO. SUPERFUND SITE**

Client: **MALONE COOPERATING PARTIES**

Project No.:	File Name:	FIGURE No.
811102.02	SITE-LOC	1

FILE NAME: MALONE-SITE-LOC.dwg
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TIME: 12:00:45

AERIAL PHOTO DATED NOV. 20, 2003

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APPROXIMATE SCALE IN FEET

MALONE SERVICE CO. SUPERFUND SITE	URS 9801 Westheimer Suite 500 Houston, Texas 77042 PH: (713) 914-6699 FAX: (713) 914-8404		SITE MAP	FILE NO. AERIAL–PHOTO
	SCALE: AS SHOWN	DRAWN BY: SJF DATE: 2–10–04		FIGURE NO. 2
		CHKD. BY: BPB DATE: 2–10–04		

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005982

DATE: June 8 2004 FILE NAME: FIG 3 - AERIAL 1969.DWG
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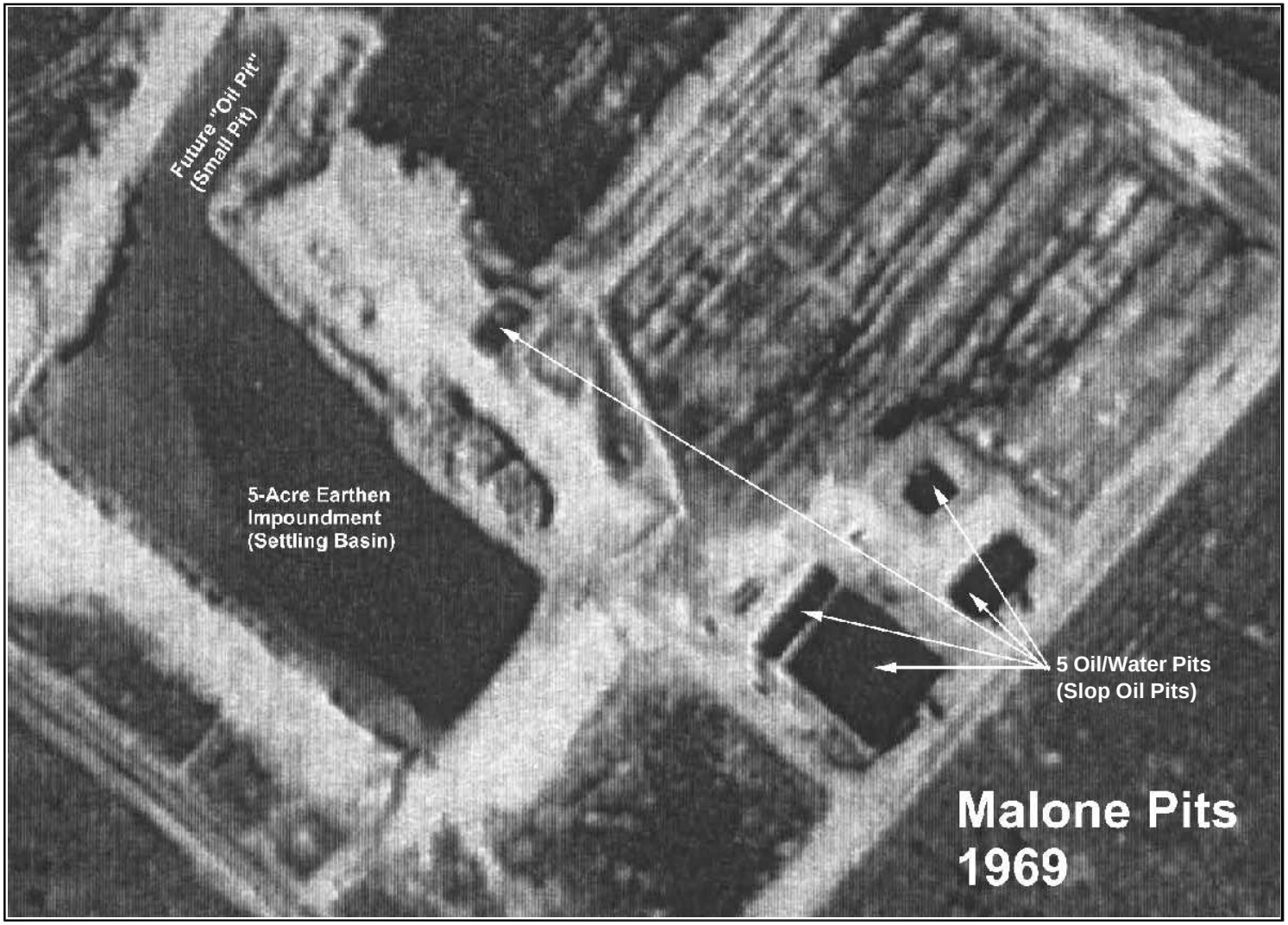

SOURCE: EPA

NOTE: DRAWING NOT TO SCALE

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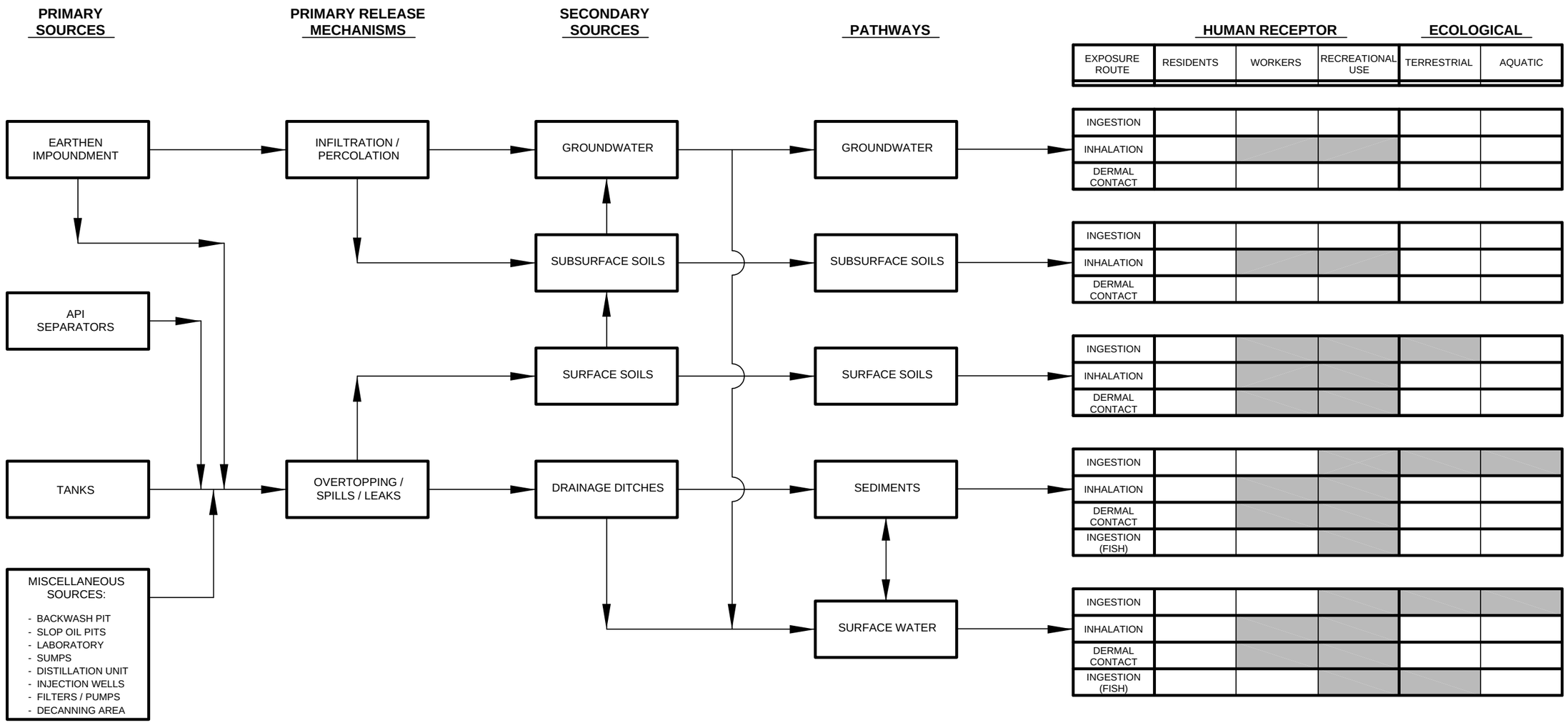
AS SHOWN	NAB	06/08/04
	Chk'd by: BB	Date: 06/08/04

Title: **1969 AERIAL PHOTOGRAPH**

Project: MALONE SERVICE CO. SUPERFUND SITE

Client: MALONE COOPERATING PARTIES

Project No.:	File Name:	FIGURE No.
811102.02	FIG 3 - AERIAL 1969.DWG	3



MALONE SERVICE CO.
SUPERFUND SITE

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CHKD. BY: BPB DATE: 3-4-04

CONCEPTUAL SITE MODEL

FILE NO. CONCEP-MODEL

FIGURE NO. 4

FILE NAME:MALONE-CONCEP-MODEL.dwg
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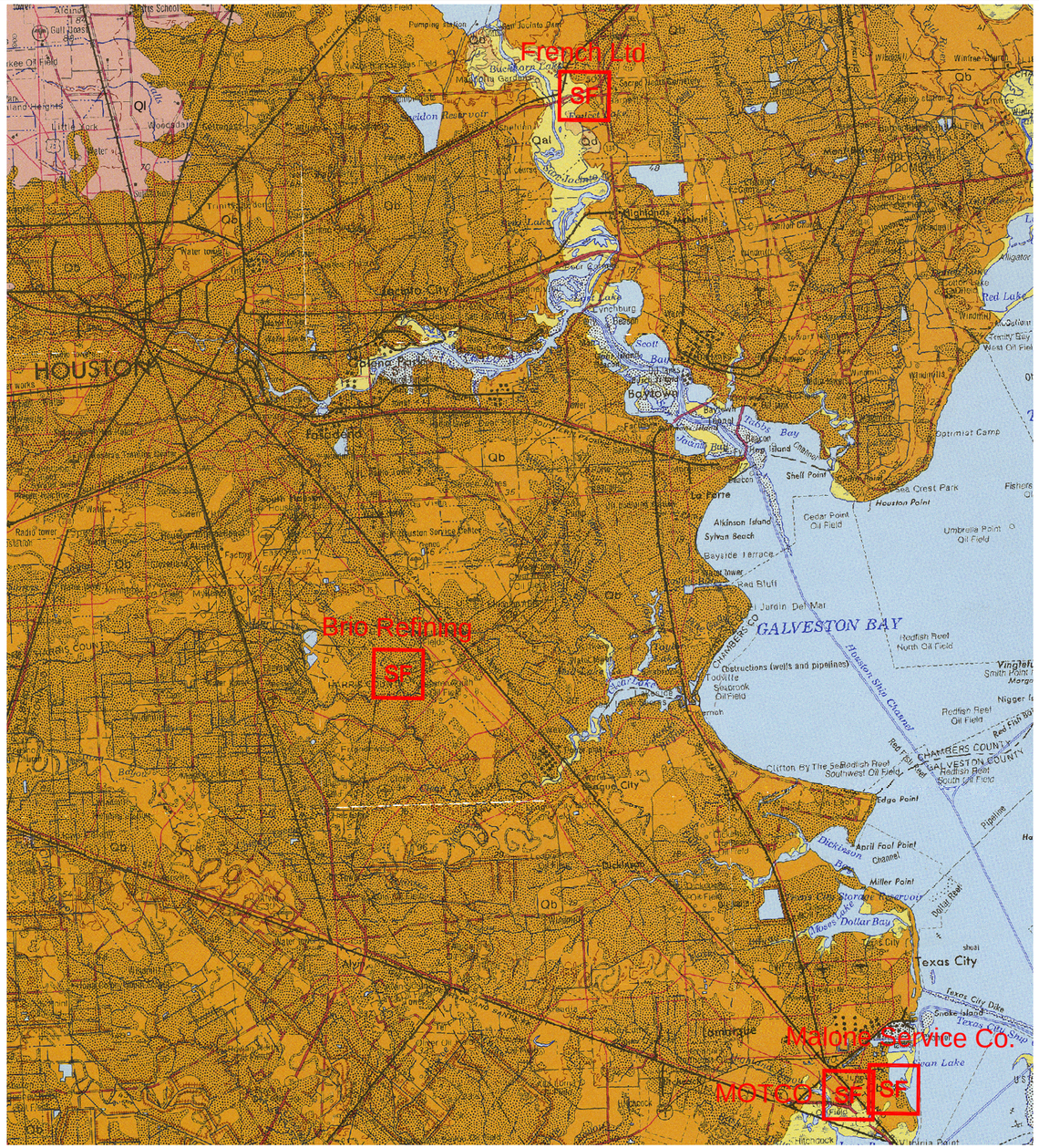
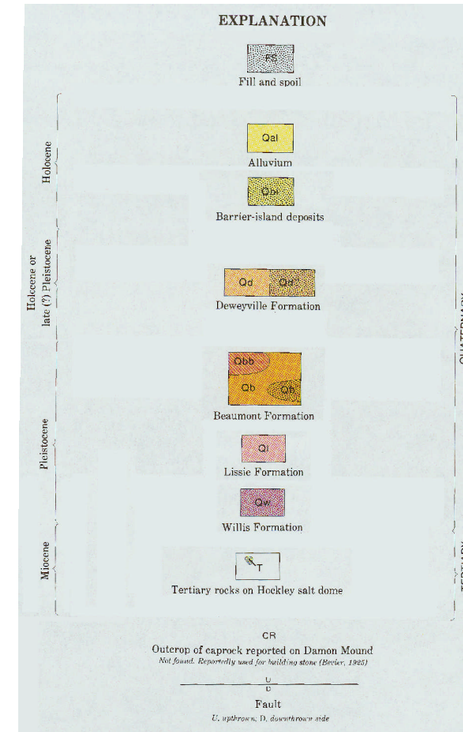
005984





SF - Superfund Site Location

Source: Geologic Atlas of Texas, Houston Sheet, Paul Weaver Memorial Edition, Revised 1982. Prepared by the Army Map Service (GUDV), Corps of Engineers, U.S. Army, Washington, D.C. Compiled in 1956 from: United States Quadrangles, 1:24,000, U.S. Geologic Survey, 1952; Texas 1:25,000, Army Map Service, 1947-49; United States Quandrangles, 1:31,680, U.S. Geologic Survey, 1919-20; USC & GS Charts 1280 and 1282, 1945. Planimetric detail revised by photo-planimetric methods. Control by USGS, CE, and USC&GS. Map filed checked 1956.

0 5 10

APPROXIMATE SCALE IN STATUE MILES
SCALE= 1:250,000

NORTH

1981 MAGNETIC DECLINATION FOR CENTER OF THIS SHEET IS 6° 00' E. MEAN ANNUAL CHANGE IS 6.3' WESTERLY.

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Title: **GEOLOGIC MAP**

Project: MALONE SERVICE CO. SUPERFUND SITE

Client: MALONE COOPERATING PARTIES

Scale:	Drawn by:	Date:	Project No.:	File Name:	FIGURE No.
AS SHOWN	DAN	5/27/04	811102.02	MALONE-GEOLOGIC-MAP.dwg	5
	Chk'd by: BB	Date: 5/27/04			

DATE:5-27-04 FILE NAME:MALONE-GEOGRAPHIC-MAP.dwg
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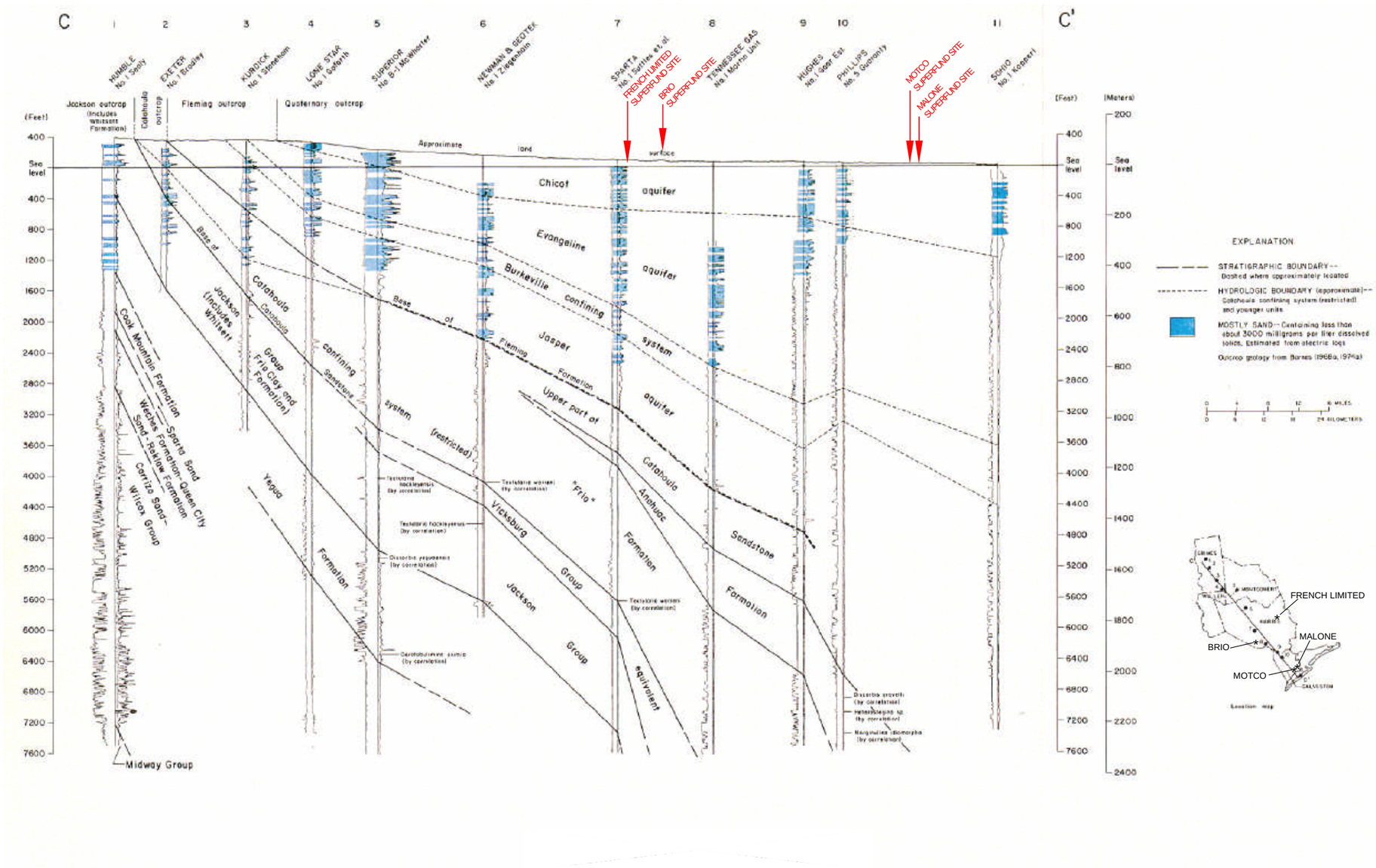

SOURCE: TEXAS DEPT. OF WATER RESOURCES REPORT 236
STRATIGRAPHIC AND HYDROGEOLOGIC FRAMEWORK OF
PART OF THE COASTAL PLAIN OF TEXAS; E.T. BAKER, JR
USGS, JULY 1979

MALONE SERVICE CO. SUPERFUND SITE	URS 9801 Westheimer Suite 500 Houston, Texas 77042 PH: (713) 914-6699 FAX: (713) 914-8404		STRATIGRAPHIC AND HYDROGEOLOGIC CROSS SECTION	FILE NO. STRATA-CROSS-SECT
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