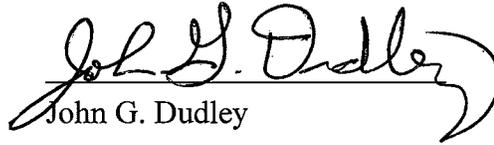


**REMEDIAL INVESTIGATION REPORT
SOIL AND NAPL OPERABLE UNIT
DEL AMO SUPERFUND SITE
LOS ANGELES, CALIFORNIA**

This remedial investigation report for the soil and NAPL operable unit at the Del Amo Superfund Site was prepared by URS in a manner consistent with the level of care and skill ordinarily exercised by professional geologists. The investigation procedures described in the report were conducted in accordance with accepted methods at the time they were performed, and the associated data and findings are technically accurate and complete.



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**DEL AMO REMEDIAL INVESTIGATION REPORT
SOIL AND NAPL OPERABLE UNIT**

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**DEL AMO REMEDIAL INVESTIGATION REPORT
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LIST OF ACRONYMS

° F	Degrees Fahrenheit
µg/l	Micrograms per Liter
AOC	Administrative Order on Consent
APN	Assessor's Parcel Number
Bgs	Below Ground Surface
BRA	Baseline Risk Assessment
BTEX	Benzene, Toluene, Ethylbenzene and Xylenes
CAA	Cupric Ammonium Acetate
CAL-OSHA	California Occupational Safety & Health Administration
CC&F	Cabot, Cabot & Forbes
CDFG	California Department of Fish and Game
CERCLA	Comprehensive Environmental Response and Compensation Liability Act
CNDDB	California Natural Diversity Database
CNPS	California Native Plant Society
COD	Chemical Oxygen Demand
COPC	Chemical of Potential Concern
CPT	Cone Penetrometer Test
CSM	Conceptual Site Model
DDT	4,4'-Dichlorodiphenyltrichloroethane
DHS	California Department of Health Services (predecessor to the Department of Toxic Substances Control)
DNAPL	Dense Non-Aqueous Phase Liquid
DPC	Defense Plant Corporation
DTSC	California Department of Toxic Substances Control
EDB	ethylene dibromide
ETC	Elastomers Technical Center
FFC	Federal Facilities Corporation
FFS	Focused Feasibility Study
FS	Feasibility Study
gpm	Gallons per Minute
GSA	General Services Administration
Hc	Henry's Law constant
HSU	Hydrostratigraphic Unit

LIST OF ACRONYMS

Kd	distribution coefficient
Koc	organic carbon partition coefficient
Kow	octanol-water partition coefficient
LADPW	Los Angeles County Department of Public Works
LADWP	Los Angeles Department of Water and Power
LARWQCB	Los Angeles Regional Water Quality Control Board
LBF	Lower Bellflower Aquitard
LNAPL	Light Non-Aqueous Phase Liquid
MBFB	Middle Bellflower B-Sand
MBFC	Middle Bellflower C-sand
MBFM	Middle Bellflower Mud
MCL	Maximum Contaminant Level
mg/kg	Milligram/kilogram
mg/l	Milligrams per Liter
MOA	Memorandum of Agreement
MOJ	Memorandum of Justification
MSL	Mean Sea Level
NAPL	Non-Aqueous Phase Liquid
NCP	National Contingency Plan
NDPA	n-nitrosodiphenylamine
OU	Operable Unit
PAHs	Polynuclear Aromatic Hydrocarbons
PCB	Polychlorinated Biphenyl
PDF	Adobe™ Portable Document Format
PEL	Permissible Exposure Limit
PES	Primary Effluent Separator
ppmv	Parts Per Million by Volume
PRG	Preliminary Remediation Goal
psi	Pounds per Square Inch
QA	Quality Assurance
QC	Quality Control
RFC	Reconstruction Finance Corporation
RFE	Request for Expenditure
RI	Remedial Investigation
ROD	Record of Decision
ROST	Rapid Optical Screening Tool

LIST OF ACRONYMS

RPFDC	Rubber Producing Facilities Disposal Commission
SDD	sodium dimethyldithiocarbamate (also referred to as shortstop)
SF	Square Feet
SVOC	Semi-Volatile Organic Compound
TCE	Trichloroethylene
UBF	Upper Bellflower Aquitard
USEPA	U.S. Environmental Protection Agency
UST	Underground Storage Tank
UV	Ultraviolet
VOC	Volatile Organic Compound
Vp	vapor pressure
WAM	Workplace Air Monitoring

REMEDIAL INVESTIGATION REPORT
SOIL AND NAPL OPERABLE UNIT
DEL AMO SUPERFUND SITE
LOS ANGELES, CALIFORNIA

1.0 INTRODUCTION

Presented in this report are the results of the Remedial Investigation (RI) for the soil and non-aqueous phase liquid (NAPL) operable unit at the Del Amo Superfund Site in Los Angeles, California. This report is presented by Shell Oil Company and The Dow Chemical Company (the Respondents) pursuant to the Administrative Order on Consent (AOC; USEPA Docket Number 92-13) between the Respondents, the U.S. Environmental Protection Agency Region IX (USEPA), and the California Department of Toxic Substances Control (DTSC). The RI was conducted by URS Corporation (previously Dames & Moore) in accordance with the Comprehensive Environmental Response and Compensation Liability Act (CERCLA), the National Contingency Plan (NCP); 40 CFR Part 300 et seq., the AOC, and the methods and procedures outlined in the following documents:

- Monitoring Well MW-20 Focused Investigation Work Plan (Dames & Moore [D&M], 1992a);
- Remedial Investigation/Feasibility Study Work Plan (D&M, 1993a) and associated addenda (D&M, 1993c, 1993e, 1994b, and URS, 2002);
- Work Plan, Pilot Program Hydraulic Extraction/Containment, MW-20 LNAPL (D&M, 1993f);
- Draft Interim Data Submittal and Proposed Laboratory Testing Program, MW-20 Pilot program (D&M, 1994d)
- Groundwater Monitoring Program (D&M, 1994a) and subsequent letters regarding revisions to the groundwater monitoring program;
- Draft Phase II Remedial Investigation Work Plan (D&M, 1994b);
- Expanded Workplace Air Monitoring Program Final Work Plan (D&M, 1994c);
- Draft Report and Work Plan, Laboratory Data and Analysis and Hydraulic Extraction Work Plan, MW-20 Pilot Program, Del Amo Study Area (D&M, 1995c);
- Proposed NAPL Screening Investigations, Soil and NAPL Remedial Investigations, Del Amo Study Area (D&M, 1997a);
- Field Sampling Plan, NAPL Screening Investigations, Soil and NAPL Remedial Investigations, Del Amo Study Area; (D&M, 1997b); and
- Remedial Investigation/Feasibility Study Work Plan Addendum - Supplemental Shallow Soil Sampling (URS, 2002).

The early RI documents were prepared with the understanding that a single RI report would incorporate findings regarding the soil, groundwater and NAPL; however, USEPA subsequently required preparation of a separate Groundwater RI. The Groundwater RI was completed in 1998 and USEPA issued a Record of Decision (ROD) describing the remedial approach for the dissolved-phase groundwater contamination in 1999. While the Groundwater RI included a discussion of NAPL, the groundwater ROD specified that decisions regarding remediation of NAPL would occur in a subsequent, second phase of remedy selection. However, since NAPL provides a continuous source of contamination to groundwater, NAPL and groundwater data and evaluation will always be linked.

This Soil and NAPL RI Report, together with the Feasibility Study (FS) report currently under preparation, are intended to provide the balance of the data and analysis necessary to support remedy selection for the soil and NAPL operable unit at the Del Amo Superfund Site. A portion of the data previously presented in the Groundwater RI Report is presented herein, to the extent that it was applicable to characterization of soil and NAPL, provided relevant background information, or was used in the risk assessment for the soil and NAPL operable unit. Findings from ongoing Groundwater Remedial Design activities are not discussed in this report, but where applicable, may additionally be considered by USEPA in preparing the soil and NAPL ROD. Groundwater Remedial Design activities to date have included installation and sampling of additional groundwater monitoring locations and modeling.

A comprehensive list of previously completed documents pertaining to soil and NAPL conditions at the Del Amo site is presented in Table 1. Applicable data from these reports is presented in this RI report, although more detailed information regarding the various investigations is presented in the individual reports

Following USEPA approval of this report, USEPA may at its sole discretion issue supplements or addenda to the report if USEPA believes that significant information needs to be added concerning the operational history of facilities, the nature and extent of contamination, or other relevant information deemed significant.

1.1 PURPOSE AND OBJECTIVES

- The primary purposes of the RI were to evaluate the nature and extent of NAPL and soil contaminants at and emanating from the Del Amo site and to provide sufficient data for completion of the Baseline Risk Assessment (BRA) and Feasibility Study (FS). Specific objectives developed in pursuit of these primary purposes included the

following: Develop an understanding of the site history to focus subsequent sampling at former rubber plant facilities where contaminants were used, stored, or disposed;

- Identify and evaluate likely contaminant source areas; and
- Evaluate the nature and extent of areas of NAPL contamination, especially in the vicinity of monitoring well MW-20 (the MW-20 NAPL).

While this RI Report provides a review of the environmental data, as discussed in Sections 6-10, evaluation of the data with respect to health risks is presented under separate cover, in the BRA (Geosyntec & URS, 2006). The risk assessment findings are used by USEPA to ascertain where remedial action may be necessary. The Feasibility Study (FS), currently under preparation, evaluates remedial options for areas identified in the risk assessment where significant health risks may exist. The FS takes into consideration site conditions and the physical properties of the chemicals present along with judgments regarding the relative effectiveness and implementability (among other factors) of various remedial alternatives. Findings from the RI, Risk Assessment, and FS are then collectively evaluated by EPA before issuing a Record of Decision (ROD), which outlines the selected remedial alternative(s) and the areas over which they will be applied.

1.2 FORMER PLANT SITE DESCRIPTION AND SETTING

1.2.1 Location

Formal boundaries of Superfund sites are usually defined by the extent of the contaminants associated with a subject facility rather than current or former property boundaries, and thus are not typically fixed or easily defined. The Del Amo RI was focused on contaminants associated with a synthetic rubber manufacturing plant formerly located on approximately 280 acres at the southwest corner of the intersection of the 405 and 110 Freeways (Figure 1). This area lies within the Harbor Gateway portion of the City of Los Angeles, adjacent to the cities of Torrance to the west, and Carson to the east (Figure 2). While recognizing the potential variability of contaminant distribution, this report is limited to conditions within the area formerly occupied by the synthetic rubber plant, hereafter referred to as the “former plant site”. The rubber plant was divided into styrene, butadiene, and copolymer plancors, as indicated on Figure 1. Styrene and butadiene produced at the plancors were combined at the copolymer plancor to form the synthetic rubber. One or more of the plancors were in operation from 1942 through 1972, after which the plant was sold, decommissioned, and redeveloped into the current business park. Aerial photographs comparing the former plant site as it appeared in 1971, shortly before demolition, and in its 2004 redeveloped condition,

are presented on Figure 3. A comprehensive discussion of the historical facilities and operations at the former plant site is presented in Section 2.

1.2.2 Climate

Southern California has a Mediterranean climate. Data from the Torrance Municipal A weather station in the vicinity of the former plant site indicate average annual precipitation is 13.6 inches (<http://www.worldclimate.com>) and occurs almost entirely between November and April. The average daily maximum temperatures range from approximately 67°F in December and January to 80°F in August. The average minimum temperature is between 45°F in January to 62°F in August. Winds are typically out of the west, with an average speed ranging between 5 and 7.5 mph (City-Data, 2006).

1.2.3 Physiography

The former plant site lies in the Torrance Plain, a relatively flat area within the broad coastal plain of the greater Los Angeles area. The Torrance Plain is wedge-shaped, opening to the southeast, and is bounded by the Rosecrans Hills to the northeast, the El Segundo Sand Hills and Palos Verdes Hills to the southwest, and San Pedro Bay to the southeast (Figure 4). The Rosecrans Hills are the local manifestation of the Newport-Inglewood structural zone, a composite faulted anticlinal belt which transects the coastal plain in a northwest-southeast direction and extends from Beverly Hills in the north to Seal Beach in the south.

The Torrance Plain has few topographic features and is only slightly dissected by local drainages. The closest surface water body is the Dominguez Channel, a man-made concrete drainage channel approximately 2,000 feet northeast of the former plant site at its closest approach. Due to the relatively arid climate and urban setting, significant surface water runoff occurs rarely, and is controlled by the local streets and storm drain system.

The historical physiography of the former plant site and vicinity was investigated through review of historical topographic maps and aerial photographs. The maps and photographs reviewed are listed in Section 15 and findings are briefly summarized below:

1896

A slough was present approximately one-half mile southeast of the former plant site. Two drainage tributaries leading to the slough were located less than one-half mile northeast and south of the study area. Another tributary appeared to have originated along the eastern boundary of the study area and may have drained the eastern portion of the area.

1927-1941

Aerial photographs from 1927 through 1941 show two small drainages in the southern portion of the future styrene plant. The two drainages merged into one within the future Waste Pit Area and flowed south from the former plant site toward a drainage tributary leading eastward. Two other parallel tributaries were present approximately 1,500 and 3,000 feet south of the former plant site, and the three tributaries merge to the east. Residential construction south of the future styrene plant was in progress over the tributary closest to the former plant site beginning in the 1941 photograph.

A small drainage was present at the northwest corner of the future styrene plant in the 1927 photograph, but was not observed on subsequent photographs. This tributary flowed to the west, away from the former plant site.

1947

The 1947 aerial photograph shows the completed former synthetic rubber plant and two man-made drainage features. The first originated to the west of the former plant site and flowed eastward toward the Dominguez Channel along the northern plant boundary and the south side of 190th Street. The second drainage feature was an L-shaped ditch within the styrene plant. Liquid was present in the ditch in some of the 1947-1973 photographs.

1951

The tributary which passed northeast of the study area was referred to as Laguna Dominguez on the 1951 topographic map. Levees were present along Dominguez Channel which drained Laguna Dominguez from the southeast. A marshy area with two small bodies of standing water was observed approximately 500 feet southeast of the butadiene plant. The southernmost tributary noted on the 1927 - 1941 aerial photographs is indicated as an intermittent stream and ephemeral water body on the 1951 map. The other two tributaries were evident based on surface elevations on the map; however, no water bodies were shown to be associated with these tributaries. A topographic gradient of approximately 30 feet per mile is evident based on surface elevations presented on the map. No surface drainage or standing water was indicated within the former plant site on the map.

1953-1965

Excavations along Laguna Dominguez were observed in the 1953 photographs. By 1956, construction of a portion of the current Dominguez Channel was complete approximately 3/4-mile north of the former plant site. Extensive excavation activities were noted to the east of the former plant site in 1958. By 1960, the tributaries previously observed south of the

styrene plancor were replaced by the Torrance Lateral drainage channel. Large excavated areas were also noted south of the former plant site.

The 1964 topographic map shows several excavations within what was previously a drainage tributary along the eastern boundary of the former plant site. No surface drainage or standing water bodies within the former plant site were indicated on topographic maps from later dates.

Features similar to those seen on the 1964 topographic map were noted on the 1965 aerial photograph. Construction of the Torrance Lateral southeast of the study area was completed up to the Dominguez Channel and the last of Laguna Dominguez was channelized. Photographs later than 1960 indicate the number of excavations east of the former plant site decreased through time. These features were observed on aerial photographs dated as late as 1989.

1973-1989

Partial dismantling of the rubber plant is apparent from the 1973 aerial photograph, although the drainage features along 190th Street and within the styrene plancor first noted in the 1947 photograph are still present. By 1976, only portions of each of the ditches remained and both were completely removed by 1980. No other surface drainage patterns were observed at the former plant site on the aerial photographs reviewed from later dates.

1.2.4 Surface Water Hydrology

Surface runoff in the vicinity of the former plant site is currently controlled through the Los Angeles County Flood Control System. Local engineered drainage structures include the Dominguez Channel, Torrance Lateral, and Kenwood Drain, as shown on Figure 5. Drainage to the above structures occurs through surface water flow to local street gutters, culverts, and storm drains.

Historical aerial photographs and topographic maps show that ancestral water courses and drainages roughly corresponded to the current engineered flood control channels. Topographically, the former plant site and vicinity exhibit a gentle eastward slope which has not changed substantially with development of the area. The land surface elevation at Normandie Avenue, west of the former plant site, has been at approximately 48 feet above mean sea level (MSL) since 1924. The elevation at Hamilton Avenue, to the east of the former plant site, has remained at about 30 feet MSL since 1924.

Minor drainage swales were present at the southern margin of the former plant site prior to development of the rubber plant in 1942. Water was only ephemerally present in these swales which drained southward through the sparsely developed residential neighborhood to a water course which was subsequently developed into the Torrance Lateral. Further details regarding historical drainage patterns at the southern site boundary of the former plant site is presented within an August 20, 1997 Technical Memorandum (D&M, 1997c).

1.2.5 Zoning, Development and Land Use

The former plant site currently includes 67 separate parcels, 62 of which are developed (Figure 6). Buildings, paved parking areas, streets, and landscaped areas currently cover more than 90% of the former plant site. Undeveloped areas are primarily at the southern end of the former plant site, and include most of Los Angeles Department of Water and Power (LADWP) parcels used for high-voltage power transmission lines (parcels 7351-033-900 and 7351-034-901), the former plant site waste pit area (parcels 7351-034-077 and -078) and an area used for roll-off bin and dumpster storage at the southwest corner of the former plant site (parcel 7351-034-070).

Zoning for the majority of the former plant site parcels (64 of 67 parcels) is designated as heavy or light manufacturing/industrial, as shown on Figure 6. One parcel, corresponding to the current Holiday Inn Hotel (parcel 7351-033-039), maintains a dual industrial - commercial zoning designation. Two parcels are zoned as “public facilities” and correspond to the LADWP utility corridor.

There are approximately 68 buildings currently on the former plant site. Building footprints range up to approximately 215,000 square feet (sf), although several buildings are multistory structures, and thus may exceed 215,000 sf of floor space. The main buildings are typically concrete tilt-up or high-rise structures and are primarily used for warehouse/freight forwarding operations, manufacturing, and office space. An inventory of known tenants at the buildings within the former plant site, as available from 2004 Internet directories, is presented in Table 2, and the general use for each parcel is shown on Figure 7.

All current structures at the former plant site are limited to business use and there are no known full-time residents. Information regarding the site worker population is not readily available; however, there are approximately 11,475 parking spaces at the former plant site based on review of recent (2004) aerial photography and interviews with property managers. This figure provides an approximate upper limit on the number of people present onsite during working hours. While multiple workers may occasionally be associated with a parking space, this is more than offset by unoccupied parking spaces. For example, a parking lot with

225 spaces in the southeastern corner of the former plant site (LADWP corridor) does not appear to be dedicated to any specific building, and is typically nearly vacant.

The area surrounding the former plant site is zoned for manufacturing/industry to the east, north, and west (Figure 6). Land uses in the vicinity of the former plant site are shown on the annotated 2004 photograph on Figure 8. Residential and industrial zoned areas border the former plant site to the south. An approximately three block portion of the residential area immediately south of the Waste Pit Area at the former plant site was razed after being purchased by Shell Oil Company and the U.S. Government in 1998 and is currently vacant. A residential area is additionally present approximately 650 feet north of the former plant site, across the 405 freeway.

Historical land use and the progressive development of the former plant site and vicinity are best summarized on Figure 9, presenting representative aerial photographs of the area from 1928 through 2004. In brief, the former plant site and vicinity were mostly undeveloped agricultural property until construction of the rubber plant in 1942. Development of the area increased significantly starting in the early 1960s, coinciding with the completion of the current Dominguez Channel and the 405 and 110 freeways near the former plant site. Demolition of the rubber plant began in 1972 and it was thereafter subdivided and gradually developed as a business park, with buildings progressively added to the parcels. Additional observations based on the photographs and maps listed in Section 15 are presented below, and details regarding rubber plant facilities and operations are presented in Section 2.

1927-1946

Aerial photographs from 1927 through 1941 indicate the former plant site was undeveloped and used for agricultural purposes. The rubber plant was first observed on a 1946 photograph.

Properties immediately surrounding the former plant site were also used primarily for agriculture. The Golden Eagle refinery was present approximately one-half mile southeast of the former plant site starting with the 1928 photograph. Some residential developments were observed south of the former plant site by 1941. Properties immediately east and west of the former plant site remained mostly undeveloped in the 1946 photograph, while some residential development was present to the north and south. Excavations were present within one-half mile northeast of the former plant site, and open excavations related to landfill activity were also observed. The McDonnell Douglas and Industrial Light Metals facilities west of Normandie Avenue were present by 1946, including two aboveground tanks at the southwest corner of Normandie Avenue and 190th Street.

1951-1962

A 1951 topographic map shows development in all areas of the former synthetic rubber plant. Features within the styrene plancor included sumps west of both ethylbenzene production units and the large storage tanks within bermed areas along the western side of the plant. Numerous aboveground tanks were also present throughout the butadiene plancor.

Trenches and excavations were noted east of the study area between 1952 and 1960. By 1954, properties adjacent to the western boundary of the former plant site were being developed. Large commercial/industrial structures were constructed north and east of the area after 1956. The residential area south of the styrene plant was fully developed by 1962.

1963-1972

The 1964 topographic map shows the addition of a gas vessel, replenishing agent tanks, and latex storage tanks within the copolymer plancor. Additional oil storage, crude toluene, finished styrene, and horizontal gas tanks were noted in the styrene plancor. Observed changes in the butadiene plancor included the additions of the skimmed oil and isoprene gas storage tanks. The 1972 topographic map appears essentially the same as the 1964 map.

1973-2004

Dismantling of rubber plant facilities was evident on photographs from 1973 through 1980. With the exception of some remnant bermed areas at the butadiene plancor, large portions of the study area were re-developed in the 1981 topographic map. Fewer new buildings were noted on the map than were actually observed on the photographs.

New buildings were noted within the former plant site on the 1976 and 1982 photographs and the 1989 photograph shows extensive redevelopment of the area. A limited number of new buildings appear at the former plant site between 1989 and 2004, most notably within the southern portion of the former butadiene plancor.

Offsite commercial and industrial development south and east of the former butadiene plancor area continued through 1989. Approximately nine acres of the residential area south of the former plant site along 204th Street were razed in 1998 and currently remains vacant. Redevelopment of the former McDonnell Douglas property west of Normandie Avenue began by 2001 and is the property currently occupied by a large retail development and large freight distribution centers.

1.2.6 Streets and Traffic Circulation

Streets at or bordering the former plant site are identified on Figure 10, and include Vermont Avenue, 190th Street, Hamilton Avenue, Knox Street, Francisco Street, Pacific Gateway Drive, Magellan Drive, and Del Amo Boulevard. Vermont Avenue and 190th Street are arterial streets, meaning that they serve high-speed, high-volume traffic and are used for travel between major points. These two streets range from four to six lanes wide depending upon the day of the week and time; one lane on each side is used for parking during off-peak traffic hours. Hamilton Avenue is a two-lane collector street, providing access between neighborhoods and arterial streets. Knox Street, Francisco Street, Pacific Gateway Drive, and Magellan Drive are local, two-lane streets, used for access to adjacent properties. Del Amo Boulevard is a little-used alley along the southwestern margin of the former plant site, but becomes a four-lane local street along the southeastern margin.

Details regarding streets in the immediate vicinity of the former plant site are presented in Table 3. The majority of vehicle traffic in the vicinity of the former plant site occurs on the 405 and 110 freeways, located near the northern and eastern boundaries of the former plant site, as shown on Figure 10.

1.2.7 Water Use

No surface water resources or groundwater production wells are known to be present at the former plant site. All water for domestic and industrial uses at the former plant site is supplied by the California Water Service Company (formerly the Dominguez Water Company). Further information regarding water use in the vicinity of the former plant site is provided within the Groundwater RI report (D&M, 1998a).

1.2.8 Biological Resources

Biological surveys and reconnaissance were conducted at the former plant site in 1991, 2001 and 2006 by Dames & Moore and URS biologists to survey the site and surrounding area and identify the characteristic, flora, fauna and habitat types present. The former plant site and vicinity have been developed for commercial, light- and heavy-industrial, and residential use for more than 60 years. The survey findings uniformly indicate that no native habitat or sensitive, endangered, or threatened species were present.

Native wildlife habitat does not exist within one mile of the former plant site. Open areas, including the Roosevelt Memorial Park, Dominguez Golf Course, Victoria Golf Course, and Victoria Park are located within a mile of the former plant site. These open areas do not provide native habitat for wildlife, although urban-adapted bird species utilize the park habitats. During bird migratory or dispersal movements, individuals of sensitive bird species

may infrequently visit the parks as transitory birds. Most of the native organisms in the vicinity, and specifically those formerly present on the former plant site, were replaced with those typical of highly developed urban areas many decades ago. Such sites typically become occupied by hardy, exotic plant species when left fallow.

Small populations of low ruderal (weedy) species occur on the few remaining vacant parcels at the southern end of the former plant site. Vegetation present includes such species as Bermuda Grass (*Cynodon dactylon*), Russian Thistle (*Salsola tragus*), Cheeseweed (*Malva parviflora*), Western Ragweed (*Ambrosia psilostachya*), Filaree (*Erodium* spp.), Black Mustard (*Brassica nigra*), and Dandelion (*Taraxacum officinale*). Numerous non-native, ornamental grasses, shrubs, and trees are additionally located on the former plant site. Habitat supporting sensitive species is found neither on nor within a mile of the former plant site. However, many common rodents and gophers inhabit the Waste Pit Area and adjacent open space parcels, and common birds also reside in the trees.

Small, remnant populations of urban-adapted amphibian and reptile species may be present in nearby residential areas, especially where gardens and landscape ground cover, such as ivy, are maintained. These species include the Western Toad (*Bufo boreas*), California Slender Salamander (*Batrachoseps attenuatus*), Western Fence Lizard (*Sceloporus occidentalis*), Southern Alligator Lizard (*Gerrhonotus multicarinatus*), and Common Garter Snake (*Thamnophis sitalis*). These are common species and none is poisonous or listed as threatened or endangered.

A few bird species typical of urban areas were observed using the former plant site at the time of the survey, including Mourning Dove (*Zenaida macroura*), Rock Dove (*Columba livia*), Common Raven (*Corvus corax*), European Starling (*Sternus vulgaris*), Brewer's Blackbird (*Euphagus cyanocephalus*), House Sparrow (*Passer domesticus*), and House Finch (*Carpodacus mexicanus*). Depending upon the character of landscaped areas that may be developed on the former plant site, other urban-adapted bird species may also be present. These include Anna's Hummingbird (*Calypte anna*), Northern Mockingbird (*Mimus polyglottos*), and American Robin (*Turdus migratorius*), among others. An American kestrel (*Falco sparverius*) was observed at the former plant site in 2006. Kestrels are not a threatened or endangered species, but are protected under the migratory bird act. No endangered or threatened species are expected to utilize the site or have been observed at the former plant site.

Urban-adapted mammals may also be present in the vicinity of the former plant site. These include the Norway Rat (*Rattus norvegicus*), House Mouse (*Mus musculus*), Botta's Pocket

Gopher (*Thomomys bottae*), and California Ground Squirrel (*Spermophilus beecheyi*). None of these species is threatened or endangered.

Information on special status species and resources in the vicinity were developed from several sources, including the California Department of Fish and Game's Natural Diversity Data Base (RAREFIND, CNDDDB [CDFG, 2006]), U.S. Fish and Wildlife Service's List of Threatened and Endangered Plants and Animals for Los Angeles County, California Native Plant Society's Electronic Inventory of Rare and Endangered Vascular Plants of California (CNPS, 2006), California Statewide Wildlife Habitat Relations System (CDFG, 1988), and existing files at URS Corporation. These data indicate that observations of sensitive resources have been: (1) recorded only from areas that are more than one mile from the former plant site, and in most cases, many miles from the former plant site, or (2) were recorded early in this century within the Torrance USGS 7.5-minute quadrangle in areas more than one mile from the former plant site or in presently urbanized habitats that no longer support populations of the species.

No impact from constituents in soil is expected on any sensitive biological resources since the natural habitat for state or federal endangered or threatened species is lacking within one mile of the former plant site. Further information regarding ecological risks at the former plant site are provided within Appendix I of the BRA (Geosyntec & URS, 2006).

2.0 RUBBER PLANT HISTORY

The investigation of the rubber plant history was originally completed in 1993, concurrent with the early portions of the RI fieldwork. The history of the rubber plant played a critical role in shaping the RI by providing a basis for selecting sampling locations, which were focused on areas of former chemical storage, use, and disposal associated with the rubber plant.

Rubber plant history information was primarily compiled and assimilated from documentation provided by Shell, which included materials in the following categories:

- Process descriptions;
- Requests for Expenditures (RFEs) and Memoranda of Justification (MOJ), typically from the 1960s, which often included a brief description of proposed improvements to a process or plant area;
- Numerous drawings, including process flow sheets and maps or schematics of plant facilities;
- Consultant reports; and
- Deposition testimonies and summaries.

Additional rubber plant history information originated from historical aerial photographs, USEPA file material for the former plant site, and various U.S. Government pamphlets and technical papers regarding rubber production facilities. The dates of the aerial photographs reviewed range from 1927 through 2004. A complete list of the photographs is provided in Section 15. USEPA file information pertained to pipelines, wastewater treatment, and the Eston Chemical Company facilities at the former plant site, while the remaining documents reviewed provided general information regarding plant waste streams and waste management practices. These documents included pamphlets produced by the Rubber Producing Facilities Disposal Commission (RPFDC, 1953a, 1953b, 1953c), the Defense Plant Corporation (DPC a,b,c) and technical papers from industry trade journals (Hebbard et al, 1947; Rostenbach, 1952; Martin and Rostenbach, 1953).

While the rubber plant history description was prepared to be as accurate and complete as possible, full documentation of the many changes to facilities and operations that occurred over the life of the former plant site is not available. In some cases, facility locations discussed in documents were not entirely clear and had to be inferred from the context or other knowledge of the former plant site. Occasionally, documents or maps were not consistent with each other. Finally, the information sources were not necessarily applicable to the entire operational period of the plant. This may explain many or all of the inconsistencies that were observed. EPA may

issue future amendments or addenda to this RI report in the event that new information or analysis becomes available.

2.1 OWNERS AND OPERATORS

2.1.1 1942-1955

On June 25, 1940, the U.S. Congress authorized the Reconstruction Finance Corporation (RFC) to create subsidiary corporations to produce and acquire “strategic and critical materials”, as defined by the President, as part of the nation’s defense program and involvement in World War II. President Roosevelt designated rubber as such a strategic and critical material on June 28, 1940. The DPC acquired title to the land for construction of a chemical production/synthetic rubber manufacturing facility in 1942. The RFC was authorized to own, operate, administer, and inspect the operations of government-owned rubber facilities under the Second War Powers Act of 1942, for which purpose it created a subsidiary, the Rubber Reserve Company. The Rubber Reserve Company had oversight responsibility for the rubber plant and other government rubber facilities from 1942 until 1945, after which it was succeeded by other subsidiaries, including the Office of the Rubber Reserve (1945-1951), the Office of Synthetic Rubber Division (1951-1952), and the Office of Synthetic Rubber (1952-1954).

RFC responsibility for the rubber plant ended in 1954, when oversight was transferred to the Federal Facilities Corporation (FFC), Office of Synthetic Rubber. FFC oversight continued until the sale of the rubber plant and property to Shell in 1955. U.S. Government association with the site was thereafter limited to legal liabilities associated with its past ownership of the rubber plant, which became the responsibility of the General Services Administration (GSA) in 1961, when the FFC was dissolved. GSA is still currently involved with the former plant site in this regard.

The rubber plant was comprised of three inter-related plantors: the butadiene and styrene plantors, where these individual chemicals were produced, and the copolymer plantor, where the butadiene and styrene were combined to produce the synthetic rubber. During the period of U.S. Government ownership between 1942 and 1955, the three plantors were operated by various companies under Agreements of Lease and Operation, as described below.

2.1.1.1 Styrene Plantor

The styrene plantor, also referred to as Plantor 929, was constructed and operated between 1942 and 1955 under agreements between The Dow Chemical Company (Dow) and the Rubber Reserve Company. Dow, acting as agent for the DPC, entered into a subcontract with Stone & Webster to produce the engineering drawings and direct construction work. Dow provided to the

Stone & Webster engineers detailed information about the styrene manufacturing process previously developed by Dow. DPC oversaw construction and retained the right to modify the work.

Plancor construction began on August 24, 1942, styrene production began on June 14, 1943, and full operation commenced on August 17, 1943. Production capacity was 25,000 short tons (2,000 lbs/ton) of styrene per year (tons/yr). Following construction, Dow operated and managed the styrene facility, as agent for Rubber Reserve, with Rubber Reserve retaining ultimate authority over plant operation.

On December 8, 1947, a one-acre tract within the southeastern portion the styrene plancor was leased by RFC to the Eston Chemical Company for the purpose of manufacturing crude ethylene dibromide (EDB). Ethylene gas produced in the styrene plancor was delivered by pipeline to the Eston facility under the terms of the lease.

2.1.1.2 Butadiene Plancor

The butadiene plancor, also known as Plancor 963, operated under agreements between Shell Chemical Company (later merged into Shell Union Oil Corporation; collectively “Shell”) and Rubber Reserve from 1942 to 1955. Shell, acting as agent for the DPC, entered into a subcontract with Stone & Webster to produce the engineering drawings and direct construction work. Shell provided to the Stone & Webster engineers detailed information about the butadiene process while DPC oversaw construction and retained the right to modify the work. Plancor construction began on September 15, 1942. Following construction, Shell operated and managed the facility as agent for Rubber Reserve, while Rubber Reserve retained ultimate authority over plant operation. Butadiene production began on July 25, 1943 and the full production capacity of 30,000 short tons/yr was reached on May 6, 1944. Butadiene production ceased on August 15, 1947, but the plant was returned to operation in November 1950.

2.1.1.3 Copolymer Plancor

The DPC and Goodyear Tire & Rubber Company (Goodyear) executed a lease agreement for the copolymer plancor, referred to as Plancor 611, on May 2, 1942. Preliminary construction of the plancor began on September 1, 1942, limited rubber production commenced in June 1943, and the plancor construction was complete and ready for full production on February 1, 1944. Goodyear signed an operating agreement for the plancor with Rubber Reserve on May 25, 1943. Goodyear operated all the production lines until September 3, 1943, after which the second and third copolymer units were operated by United States Rubber Company (U.S. Rubber, predecessor of Uniroyal, and later, Michelin North America Inc.). The maximum production

capacity of the plant was 100,000 short tons/yr, although this rate was only intermittently achieved.

On July 21, 1947, the two U.S. Rubber production lines were placed on standby and shut down. The first copolymer unit continued to be operated by Goodyear until April 1949, at which time it was also deactivated. Goodyear maintained all three of the production units during the inactive period. Minnesota Mining and Manufacturing Company (3M) reactivated two of the production lines on August 28, 1950. 3M assigned its operating agreement to the Midland Rubber Corporation on June 21, 1951, who operated the plant until April 25, 1955.

2.1.2 1955-1972

The FFC sold the rubber plant property and facilities (all three plants) to Shell in 1955. Shell continued to operate the three plants and produce rubber until 1969, when operations were gradually reduced. The butadiene plant was shut down first, except for the Elastomers Technical Center (ETC; also identified as “technical center/shops/research laboratory”). The copolymer plant relied on purchased butadiene to complete some contracts after the closure of the butadiene plant. The entire rubber plant facility (except for the ETC; see Section 2.3.3.5 for details) was permanently shut down by September 1, 1972 in preparation for its sale.

2.1.3 1972 - Present

Shell decommissioned and sold the rubber plant property “as is” to Cabot, Cabot & Forbes (CC&F), a land development company, in 1972. CC&F dismantled the facilities, subdivided the property for development as a business park, and began selling portions of the former plant site. In March 1976, CC&F entered into a partnership with Cadillac Fairview/California, Inc. (Cadillac Fairview) for continued commercial development of the remainder of the property. This partnership was terminated in October 1976, with Cadillac Fairview acquiring the remaining unsold property. Cadillac Fairview thereafter continued to progressively sell the former plant site parcels. The 280-acre former plant site presently consists of 67 parcels with numerous property owners, and has been almost completely developed with industrial and commercial facilities. Details regarding current parcel owners, occupants and land use for the former plant site are provided in Table 2 and on Figure 7.

The majority of the Waste Pit Area, including the pit 1B, 1C and 2A-2F areas (currently parcel 7351-034-077), was purchased from Cadillac Fairview by Triton Diagnostics in 1994. Triton Diagnostics (a subsidiary of Shell) remains the current owner. The eastern portion of the Waste Pit Area, including pit 1A and the eastern evaporation pond (currently parcel 7351-034-078), is currently owned by Waste Management Inc.

2.2 REGULATORY AGENCY OVERSIGHT

Regulatory agency oversight of environmental investigations at the former plant site began in 1982 when Western Waste initiated excavation of waste pit 1A under the direction of the State of California, Department of Health Services (DHS; predecessor to the Department of Toxic Substances Control). G.P. Holdings (a subsidiary of Cadillac Fairview), Dow and Shell entered into a Memorandum of Agreement (MOA) with the State of California in 1985 under which DHS contractors evaluated the nature and extent of contamination at the Del Amo Waste Pit Area. These parties subsequently signed an Administrative Order with the State of California (No. 87/88-041) on March 18, 1988, under which the previous studies would be incorporated into RI and FS reports for the Waste Pit Area. Although these reports were issued in 1990 and 1991, respectively (D&M, 1990, 1991) DTSC issued a Notice of Non-Compliance in October 18, 1991, which terminated the original State Order. Primary oversight responsibility was transferred to USEPA when Shell and Dow (the Respondents) subsequently signed an AOC with USEPA (USEPA, 1992b) on May 7, 1992, under which an RI/FS for the broader Del Amo site (the former plant site and surrounding impacted area) and a Focused Feasibility Study (FFS) for the Waste Pit Area were to be conducted.

USEPA divided the Del Amo site into the Soil and NAPL operable unit (OU1), the Waste Pit Area operable unit (OU2), and the Groundwater operable unit (OU3) for investigation and reporting purposes in 1995 during the course of the RI/FS and FFS investigations. The Waste Pit FFS was completed in 1996 (D&M, 1996b), and USEPA subsequently issued a Record of Decision (ROD) for this operable unit (1997). The groundwater RI was completed (D&M, 1998a) and USEPA subcontractors issued dual site groundwater FS and risk assessment documents pertaining to both the Montrose and Del Amo Superfund Sites (CH2MHill, 1998; McLaren Hart, 1998) in 1998. USEPA issued the dual site groundwater ROD in 1999 (USEPA, 1999a).

An engineered cap was completed in the Waste Pit Area in 2000, as directed by the Waste Pit Area ROD. The Del Amo site as a whole was listed on USEPA's National Priority List of Superfund sites in September 2002. An additional remedial action for the Waste Pit Area directed by the ROD, soil vapor extraction, was initiated in 2006. Initial remedial design work for the groundwater operable unit is currently in progress.

This Soil and NAPL RI report, together with the FS report and the recently completed BRA for the Soil and NAPL operable unit (Geosyntec & URS, 2006) will provide USEPA with the information necessary to issue the ROD for the remaining Del Amo Soil and NAPL operable unit.

2.3 PLANT OPERATIONS

2.3.1 Overview

Details regarding the facilities, processes, and operations involved in the production of synthetic rubber are summarized in the following sections. The locations of former plant site areas and facilities referred to are indicated on Figure 11, the historical base map. Historical facility locations are accurate to within ± 5 feet on this photogrammetric map, which was prepared using stereo pairs of aerial photographs taken in 1972, just prior to the sale and demolition of the rubber plant. Numerous revisions to the map were incorporated as knowledge of historical operations increased, so that the map presents all known facility locations rather than just those that existed in 1972. This map was critical in developing the RI scope, as it allowed identification of areas where chemical use, storage, disposal, and release occurred.

The use of the facilities presented on the map is labeled, as known from the documentation reviewed. In some cases, the facility use is not known and is therefore unlabeled. Similarly, the types of chemicals within various tanks and containers are labeled when known. However, documentation was sometimes sufficient to indicate a chemical was used in a general area, but insufficient to indicate exactly where it was stored. In these cases, the chemical is discussed in the text but no storage facility is identified on the map.

The synthetic rubber plant consisted of three interrelated planters: the butadiene and styrene planters, where the primary chemical components of rubber were produced, and the copolymer planter, where the butadiene and styrene were polymerized to produce synthetic rubber. Raw materials were received via surface transport (truck and rail) and aboveground and underground pipelines. Raw materials and finished products were primarily stored in aboveground tanks at the plant. Physical properties of the primary organic compounds present at the three planters are presented in Table 4.

The three planters were each equipped with a primary wastewater treatment system. Effluent from these individual primary treatment systems was collected and routed to a common wastewater treatment unit at the northeast corner of the butadiene planter for final neutralization and treatment prior to discharge to the sanitary sewer or the Dominguez Channel. Waste disposal pits in the southern portion of the styrene planter were additionally used during a portion of the rubber plant's operational period. The Waste Pit Area included four evaporation ponds (the 1-series pits and the eastern evaporation pond) and six waste pits (the 2 series pits), as shown on Figure 11. The 1-series pits received aqueous waste streams and the 2-series pits received generally semi-viscous to viscous process wastes from the styrene planter. Further information regarding the Waste Pit Area is presented in the FFS (D&M, 1996b).

The plancors were subdivided during their time of operation into numerically identified operational areas based on the processes and functions performed. This numerical identification of plant areas is retained on Figure 11 to aid the reader in locating the areas and associated facilities discussed below.

2.3.2 Styrene Plancor

The styrene plancor, designated plancor 929 by the DPC, consisted of approximately 106 acres, the more northerly 92 of which were fenced and formed the main operational area of the plancor. The primary feedstocks for styrene manufacturing were propane and benzene. Other chemicals used or produced in the process include toluene, ethylbenzene, styrene, caustic, hydrochloric acid, sulfuric acid, and smaller amounts of ethylchloride, aluminum chloride, iron-oxide catalyst (“Shell 105”), and tertiary butyl catechol. By-products produced included heavy oils, tar, and coke¹. Styrene production was divided into two north-south production lines consisting of areas 1200-1400 and 2200-2400, as shown on Figure 11. Production began by thermally cracking propane to produce ethylene, which was further purified by distillation. Benzene was supplied to the plancor in either a crude form that required purification or as a refined feedstock, depending upon availability. The ethylene and benzene were then combined in an alkylation process to form ethylbenzene, and the resulting mixture was purified through settling and fractionation² steps. Styrene was produced by dehydrogenation of the ethylbenzene, and then purified through fractionation steps.

Historical plant drawings identify 10 individual styrene plancor operating areas:

- 1000 Area - steam and water treatment plants;
- 1100 Area - ethylene production;
- 1200 and 2200 Areas - ethylbenzene production;
- 1300 and 2300 Areas - styrene production and propane cracking;
- 1400 and 2400 Areas - styrene finishing and benzene purification;
- 2000 Area - ethylene purification;
- 2500 Area - tank farms; and
- 2600 Area - administration, support, and wastewater treatment facilities.

¹ “Coke” was not defined in the site documentation reviewed but in common usage refers to a solid carbon material from which volatile compounds have been removed.

² “Fractionation” is the separation of a substance into its component fractions. While details regarding this process at the rubber plant were not available, fractionation is typically completed through a “fractionation column” where a liquid is heated and vaporized to rise through the column. The vapor gradually cools as it rises, condensing back into a liquid state. The components are separated in the column according to boiling point, with heavier hydrocarbons condensing at the higher temperatures in the lower portions of the column, and lighter hydrocarbons condensing at progressively lower temperatures higher in the column.

Additional operational areas not given formal designations on historical plant drawings include the Eston Chemical Company EDB production facility (south of the 2000 area) and the Waste Pit Area at the southern end of the plant. The Waste Pit Area was investigated as a separate operable unit. The following sections further describe the operations and facilities within each of the numbered areas.

2.3.2.1 Steam Plant and Wastewater Treatment - 1000 Area

The 1000 area was located in the northwest corner of the former styrene plant. Boilers at the steam plant provided low-pressure steam to both the styrene plant and the copolymer plant to the north. The boilers ran exclusively on fuel oil from 1955 onward. The boilers ran on natural gas, or fuel oil when the gas was not available, prior to 1955. Two large fuel oil storage tanks, each with a capacity of about 3,000 barrels (126,000 gallons), were located along the southern border of the 1000 area. The tanks were constructed using reinforced concrete in 1942 and were 45 feet in diameter, with about half the tank height (5 feet) below ground surface (bgs). Earthen containment dikes were constructed around the perimeter of the two tanks in approximately 1960.

The water treatment area was located north of the steam plant. Records indicate that oily condensate return water from the plant was treated and then used in the steam plant or returned for use in the styrene plant. Chemicals used in the treatment process included lime, caustics, and hydrochloric acid. An "acid house", presumably for acid storage, was present in the northern portion of the area.

2.3.2.2 Ethylene Production - 1100 Area

Ethylene production was accomplished through dehydration of grain alcohol through the end of 1946. Grain alcohol was heated to 800°F and was dehydrated in the presence of a catalyst. The ethylene product was purified by compression to 100 pounds per square inch (psi) followed by water washing and drying. Unconverted alcohol was recovered from the wash water by fractionation in a separate alcohol recovery unit. The ethylene production unit was taken out of service at the end of 1946 and partially dismantled (Carlstrom, et al., 1955). From the end of 1946 until August 1947, ethylene was produced by purification of a gas stream from Southern California Gas, after which it was produced by thermal cracking of propane in the 1300 and 2300 areas (see description of these areas below). The Polystyrene Process Manual (Thayer and Tymstra, 1958) indicates that the ethylene production plant may have been used in the 1960s for the production of development quantities of polystyrene.

Facilities identified in the 1100 area include the ethylene production unit, two caustic storage tanks, an alcohol recovery unit, and two "foam houses."

2.3.2.3 Ethylbenzene Production - 1200 and 2200 Areas

The production of ethylbenzene involved the drying of benzene, ethylation of dried benzene in the presence of a catalyst to form ethylbenzene, a catalyst complex settling and neutralization step, and a fractionation step to remove unreacted benzene, ethylbenzene, and related compounds. Chemicals used or produced in this process included benzene, ethylene (in gaseous form), ethyl and polyethylbenzenes, hydrogen chloride, ethylchloride, aluminum chloride, caustic, heavy oils, and tars.

The 1200 area was additionally used for production of isopropylbenzene for approximately three years, beginning in August 1944. The isopropylbenzene was produced by alkylation of propylene with benzene. The produced isopropylbenzene was transported offsite for use in production of aviation fuel. Information regarding the transport method was not available.

A tank farm containing approximately ten 20,000-gallon aboveground tanks was located in both the 1200 and 2200 areas. The tanks were located in a concrete diked area west of each production unit. Tank contents included spent caustic, benzene, ethylbenzene, ethylene, polyethylbenzene, and tar bottoms. These tanks were subject to corrosion, which could become severe over time (Shell, 1970a). Two vertical storage tanks containing caustic were present south of the tank farm, along with at least one additional tank containing ethylchloride. A concrete lined sump was located along the length of the western edge of each tank farm. A drywell of unknown construction, date and use was located in the southwest corner of the 1200 area.

2.3.2.4 Styrene Production and Propane Cracking - 1300 and 2300 Areas

Styrene was produced through dehydrogenation of ethylbenzene and occurred in reactors located north of the propane cracking furnaces. The chemicals used or produced in the reaction included benzene, toluene, ethylbenzene, polyethylbenzenes, propyl- and butylbenzene, an iron oxide "Shell 105" catalyst, and small amounts of chromium and potassium.

Propane cracking (splitting of propane into smaller hydrocarbons) was used to produce ethylene from 1947 onward. Heavier feedstocks, including butane (C4) and cyclohexane (C6) were used for cracking after Shell began operating the styrene plant in 1955.

Propane cracking occurred within five cracking furnaces within the units. According to the Styrene Process Manual (Carlstrom et al., 1955), propane was vaporized, mixed with steam, and fed to the furnaces at 425°C. The cracked product left the furnaces at 780°C and was quenched to 110°C. The cooled product was sent via a common header to the ethylene purification unit.

The crude ethylene mixture also included hydrogen, methane, ethane, propane, propylene and small amounts of longer chain hydrocarbons and acetylenes.

Tar and coke were the byproducts of propane cracking. Oily quench water generated during cooling of the cracked propane mixture represented the largest load to the 2600 area effluent basin. Blowdown, consisting of the heavy tar, coke, and hydrocarbon vapors removed from steam-pressurized vessels, was deposited in blowdown pits of unknown construction, just south of the propane cracking furnaces. The blowdown pits were moved approximately 125 feet further south in 1960 to reduce the fire hazard caused by the liberation of steam and hydrocarbon vapor from the cracking furnaces.

Large tanks were used for oil separation from the quench water and the blowdown pits. A large oil/water separator tank (about 20,000 gallons) was located west of the furnaces. An additional large vertical tank was reportedly installed in about 1965 near the northwest corner of the 1300 area to provide further separation of oil from the quench water so that the waste load to the effluent basin could be reduced. The tank was not observed on air photographs however, and is therefore not indicated on Figure 11.

2.3.2.5 Styrene Finishing and Benzene Purification - 1400 and 2400 Areas

Crude styrene was purified, or finished, by fractionation in the 1400 and 2400 areas. The fractionation products include benzene, toluene, and ethylbenzene from the crude mixture. Small amounts of sulfur were added to inhibit polymerization of the styrene. Tertiary butyl catechol was used as an inhibitor in the ethylbenzene column. Crude benzene was purified by an acid refining process that included distillation, acid washing, neutralization, and fractionation. Chemical compounds used or produced in the process included toluene, xylenes, aluminum chloride complex, sulfuric acid, sulfur compounds (thiophenes), olefins, and acid sludge.

A series of 20,000-gallon horizontal tanks was located west of the process areas in each unit. The tanks contained benzene, toluene, ethylbenzene, recycled isopentane, and recycled styrene. Equipment location plans (Shell drawings YT-5034 and YT-5037) indicate that the tanks in each farm may have been located in a sunken pit, but it was unclear whether the pit was lined. Aerial photographs indicate that the tanks in the 2400 area were above grade, but covered with soil. Isopentane was stored in a single horizontal tank at the south end of the process area in the 1400 area. Two vertical tanks located north of the tank farm in the 1400 area contained sulfur tar oil and slop oil. Acid sludge was stored in tanks located south of the tank farm in the 1400 area.

2.3.2.6 Ethylene Purification - 2000 Area

Purification of crude ethylene occurred in the 2000 area and consisted of compression, drying, refrigeration and fractionation steps. The fractions produced included C1 through C4 hydrocarbon chains, including 1,3-butadiene. The butadiene fraction was stored in the 2000 area and transferred by pipeline to the butadiene plant. A resin fraction was withdrawn from the bottom of the final fractionation column, cooled, stored in the 2500 area, then either sold or used as fuel. Aboveground storage tanks containing butadiene, ethylene, propylene, ethane, ammonia, oil/water and “resin feed” (composition unknown) were identified in the 2000 area.

2.3.2.7 Tank Farm - 2500 Area

A tank farm for bulk storage of crude and refined products from the styrene plant was located in the 2500 area. Benzene, ethylbenzene, styrene, toluene, polyethylbenzenes, propylbenzene, butylbenzene, and resin fraction were stored in large vertical tanks along the western border of the plant. Fuel oil was stored in a very large tank at the southern end of the area and in a large tank at the northern end of the area. Each tank or group of tanks was contained by earthen berms.

Several historical documents refer to spills that occurred during transfer of materials to and from tank cars and trucks. One RFE indicates the need for lighting at the finished styrene tanks because the tanks were typically filled during night hours and overflowing occurred (Shell, 1968). Another RFE described a proposal to enclose the pump for the very large fuel oil tank at the southern end of the 2500 area (Shell, 1971).

2.3.2.8 Administration, Support, and Wastewater Treatment - 2600 Area

The 2600 area wrapped around the perimeter of the styrene plant and included various plant support facilities. The northern 2600 area included acid and brine storage containers, a dry well, a cooling tower, slop oil and spent caustic tanks, and wastewater treatment facilities. Facilities in the eastern portion of the 2600 area included a warehouse, machine shops, a garage and fire station, a laboratory, cafeteria, and administrative buildings. The southern area included a substation and flare stack, while the western 2600 area included a cooling tower, and an evaporation pond. No details regarding operations at the above facilities were available, with the exception of the wastewater treatment facilities, which are discussed below.

2.3.2.9 Waste Handling and Treatment

The wastewater treatment facilities at the northern end of the styrene plant included a concrete-lined primary skimmer basin, and an additional secondary skimmer basin and associated recovered oil tank. The primary skimmer treated wastewater, storm water runoff, and runoff of leaks and spills within the plant. Acidic plant effluent was neutralized and solids were settled in the skimmer basin. Sludge at the bottom of the skimmer was periodically

removed and placed in evaporation ponds in the southeast corner of the plancor (Shell, 1966c). Modification of a caustic tank to store sludge from the skimmer was proposed so that the evaporation ponds could be abandoned. The secondary skimmer is inferred to have handled wastewater from both the copolymer and styrene plants.

Martin and Rostenbach (1953) reported that wastes produced at the styrene plancor included oily, sludge containing salts. The material was separated into an oily fraction and an oil-free fraction consisting of an approximately 30 percent aqueous solution of aluminum chloride. The oily fraction was used for boiler feed and the oil-free fraction was used as a weed killer, achieving a beneficial use for wastes that previously required disposal. Acidic oily liquid wastes from the plancor were treated by settling the solution in the primary skimmer basin to remove the oil. The liquid then entered the secondary skimmer basin where it was neutralized with an alkaline sodium aluminate solution to precipitate aluminum hydroxide. Effluent from the secondary basin contained little to no turbidity and no visible oil, and was passed on to the straw filters at the plant-wide treatment facilities in the northeast corner of the butadiene plancor, and thereafter to the Knox Street drain and the Dominguez Channel. Sludge from the separators was removed and placed on sludge beds.

Waste process water and storm water at the plancor were collected in below-grade ditches and sewer lines and also conveyed to the primary skimmer basin and plant-wide treatment facilities as described above. Surface runoff at the plancor drained to a concrete-lined ditch located along the eastern border of the 2200, 2300, and 2400 areas that discharged to the primary skimmer.

Waste disposal impoundments were present in the southern portion of the styrene plancor in the area designated as the Waste Pit Area. The Waste Pit Area included four unlined evaporation ponds, and six unlined waste pits. The evaporation ponds received aqueous wastes and the waste pits generally received more viscous process wastes generated from the styrene plancor. Waste materials in the pits and ponds are characterized by high concentrations of aromatic volatile organic compounds (VOCs), principally benzene, toluene and ethylbenzene, as well as polynuclear aromatic hydrocarbons (PAHs), principally naphthalene. The chemical characteristics of the waste materials in the Waste Pit Area are fully described in the Phase I Treatability Study Report (D&M, 1993d) and in a Data Summary Report (D&M, 1996a).

2.3.2.10 Eston Chemical

Eston Chemical operated an EDB production facility within the styrene plancor between 1948 and 1963. The facility was located south of the 2000 area. According to letters dated April 30 and June 30, 1984 from Kerr-McGee Corporation (successor to Eston Chemical Company) to DTSC, approximately 8,000 pounds of EDB per day were produced at the facility using ethylene

and bromine gas. The letters further state that with the exception of caustic used to clean process equipment, no byproducts or wastes, hazardous or otherwise, were generated, transported, or disposed of in connection with the EDB facility. The caustic may have been disposed of in an industrial sewer system.

A dry well was indicated within the foot print of the Eston Chemical facility in some documentation, but information regarding its dates of use and the nature of any liquids that may have been disposed there was not available.

2.3.3 Butadiene Plancor

The butadiene plancor, designated plancor 963 by the DPC, consisted of approximately 90 acres in the southeastern portion of the rubber plant. Butadiene is a gas at standard temperature and pressure. It was produced at the plancor through dehydrogenation of butylene and butane (also gases) followed by purification. The purified butadiene was piped to the copolymer plant, where it was polymerized with styrene to produce the synthetic rubber.

The feedstock for butadiene production was a mixture of butane, butylene, and butadiene gas that was received via pipeline from the Southern California Gas Company and the Shell Oil refinery (refinery location not specified) as well as by tanker truck from a butane dehydrogenation plant in El Segundo. Butadiene was also recycled from the styrene and copolymer plancors. Absorption oil, acetic acid, acetone, ammonia, caustic soda, liquid chlorine, sulfuric acid, hydrated lime, soda ash, copper, and dehydrogenation catalyst (Shell 205) were also used in butadiene production.

The numerically identified plancor operational areas are presented on Figure 11 and further described below.

2.3.3.1 Purification and Distillation - 100 Area

Purification and distillation of butadiene feedstocks occurred in the 100 area. Propylene was separated from the feedstock by distillation. Feedstock and raffinate³ from the cupric ammonium acetate (CAA) extraction unit were fed to the acid unit, where isobutylene was removed by cold acid polymerization using sulfuric acid. Butanes were separated from butylenes by fractionation in the presence of aqueous acetone solvent. Butadiene was separated by extraction leaving isobutylene and n-butylene. The purified n-butylenes were then catalytically dehydrogenated to produce butadiene. Aqueous CAA solvent was used in butadiene purification, as well as acetone, caustics, and acids.

³ Raffinate was not defined in the historical documentation. This term typically refers to the portion of a solution remaining after extraction of a solute.

Equipment in the 100 area included boilers, a monomer storage and unloading system, a waste solvent storage system, a recovered solvent purification system, a vent, relief, and flare system, and storage tanks containing “C5”, isoprene, acid, caustic, acetone/acetonitrile, and slop oil. The exact location of the vent, relief and flare system within the 100 area is unknown and therefore it is not indicated on Figure 11. The solvent in the storage and purification systems is inferred to have been CAA.

2.3.3.2 Catalytic Dehydrogenation - 200 Area

Butylenes produced in the 100 area were converted to butadiene in the catalytic dehydrogenation unit. Dehydrogenation occurred in two production trains, each made up of a butylene heater, a combined steam generator and superheater, and a pair of reactors. Purified butylene was vaporized, mixed with steam, and heated in the butylene heaters prior to entering reactors where dehydrogenation occurred through a bed of Shell 205 catalyst. Facilities in this area included a boiler house, butylene heaters, and dehydrogenation reactors.

2.3.3.3 Gas Recovery - 300 Area

Undesirable hydrocarbons, including propane and other lighter compounds that were produced as the result of the dehydrogenation process in the 200 area were removed from the product in the 300 area. Gases and steam were quenched in an oil stripper scrubber, where heavy polymers were removed. The gases were then condensed in an exchanger-type cooler, compressed and partially liquefied. Liquefied hydrocarbons were fractionated to eliminate by-products and recycled to the extraction distillation unit for butane removal or processed in the purification system for extraction of butadiene. Reaction products that were not liquefied were subjected to oil absorption for recovery of desired hydrocarbons. Facilities in the gas recovery area included compressors, heat exchangers, a neutralizing basin, and a control house.

2.3.3.4 Butadiene Purification - 400 Area

The butylene-butadiene mixture was routed to the product purification unit in the 400 area where butadiene was extracted with aqueous CAA solvent. The extraction was conducted at low temperature to maximize recovery and selectivity. Butadiene was removed from the rich CAA solvent extract by vaporization, then washed with water for ammonia removal, liquefied by ammonia refrigeration, inhibited to prevent polymerization, and transferred to the 600 area for bulk storage. Equipment in the 400 area included compressors, exchangers, and settlers. Numerous above ground tanks were additionally present for storage of caustic, “hydrocarbon”, “NN₂”, acetic acid, oil, CAA solvent, and finished product, as indicated on Figure 11.

2.3.3.5 Administration, Support, and Waste Handling - 500 Area

The 500 area was located primarily along the perimeter of the butadiene plancor and included general administration, support and waste treatment facilities. As indicated on Figure 11, the 500 area can be subdivided into sub-areas of waste handling to the north, administration, shops and laboratory buildings to the east, water treatment and steam production areas in the central interior area, and cooling towers to the west.

Waste Handling

Wastewater storage and treatment facilities that served all three plancors were located in the northeast corner of the butadiene plancor. The treatment facility handled approximately 2,075 gallons per minute (gpm) of process water, including 175 gpm from the styrene plancor, 1,100 gpm from the butadiene plancor, and 800 gpm from the copolymer plancor. Storm water surface runoff from the plant was collected and treated in this area, while sanitary wastes were handled separately, and discharged to the sanitary sewer. Wastewater that had already received primary and sometimes secondary treatment at plancor-specific facilities was transferred to the area via underground pipelines and/or open ditch for treatment, discharge, or recycling. Some of the wastewater was temporarily stored in tanks to allow discharge during non-peak hours. Treatment included straw filters for removal of debris and oil, gravity separation and skimming in settling basins, and adjustment of pH. Discharge from the treatment facility entered the Knox Street drain at the northeast corner of the plant site and discharged to the Dominguez Channel. The Knox Street drain route is shown superimposed on a 2004 aerial photograph of the former plant site vicinity on Figure 12. The Dominguez Channel is located approximately 0.4 miles east of the former plant site and is a regional, concrete-lined drainage that flows to the Los Angeles Harbor near Long Beach.

A permit was granted for the plant to discharge treated wastewater to the Dominguez Channel in 1945. Permit standards were as follows:

- Solids not to exceed 1 milligrams per liter (mg/l);
- Oil, grease, fats, and waxes not to exceed 25 mg/l;
- No garbage or domestic sewage;
- pH at or above 6.5 and at or below 10.0;
- Toxics “less than toxic concentration”; and
- Temperature not to exceed 140°F.

A July 1968 letter from the Los Angeles Regional Water Quality Control Board (LARWQCB, 1968) to Shell refers to waste discharge requirements established in February 1968. The discharge requirements are not stated in the letter with the exception of chemical oxygen demand, which was limited to 845 pounds.

The following facilities were involved in wastewater treatment and are identified on Figure 11:

Wastewater holding tank	Neutralizing basin
Effluent straw filter	Two oil skimmer basins
Filtration tank	Two slop oil tanks
Skimmer basin	Two recovered oil/absorber oil tanks
Two unlined impoundments	Filtration tank

The unlined impoundments may also have been referred to as “chemical basins” in some documentation.

Slop oil recovered from the skimmer basins was pumped to a fuel oil storage tank on the plant. The unlined impoundments received water containing caustic, acid, and copper solution that was neutralized before discharge to the Knox Street drain. Waste treatment improvements in 1951 resulted in discharge of the copper solutions to the sanitary sewer rather than into the Knox Street drain.

Slurries and sludge mixtures that could not be handled by the wastewater treatment system were either hauled away by vacuum truck (destination unknown) or pumped to the 1-series pits in the Waste Pit Area (operational period: 1965-67) for draining and drying and subsequent removal. Waste gases were burned at the flare stack. Waste materials were also occasionally disposed of in the burn pit or the incinerator in the waste handling area. An “acetylene dump” was also present in the waste handling area. The construction and use of this facility is unknown. Acetylene is a gas under standard temperature and pressure conditions.

Administration, Shops and Laboratory

Facilities in the eastern portion of the 500 area included a cafeteria, guardhouse, administration building, garage and fire station, boiler house, change house⁴, equipment building, technical center/shops/research laboratory building (also referred to as the “Elastomers Technical Center”, or ETC), and a storehouse/research building. Details regarding operations at these facilities are generally not available, with the exception of limited information regarding the ETC, as discussed below.

A letter from Shell to Los Angeles County in 1972 indicates that the ETC continued to operate after the remainder of the rubber plant had been shut down in September 1972 (Shell, 1972b). The ETC was not planned for shut down until 1975, although it is unclear whether this schedule

⁴ A “change house” is where workers washed and changed clothes

was followed. Aerial photographs indicate the ETC building was still present in March of 1976, when most of the other rubber plant facilities had already been demolished. The laboratory building was no longer present in a 1979 photograph.

A letter from Shell to the LA County Sanitation District (Shell 1972b) indicates that wastewater from the ETC had previously been commingled with wastewater from the main plant and discharged to the sewer after treatment. Shortly after shutdown of the plant in September 1972, ETC wastewater was redirected to the Shell Dominguez Refinery through a pipeline, where it was similarly commingled with effluent from the refinery, treated, and discharged to the sewer.

A memorandum from the ETC director to the Shell Wilmington-Dominguez refinery (Shell, 1972a) requested consideration of ETC waste disposal at the refinery and indicated the waste would contain the following constituents:

Cyclohexane	Isopentane
Ether	Alcohols
Isoprene	Styrene
Butadiene	Diethylene dibromide
“Non-volatile hydrocarbons”	

Documentation regarding the ETC includes an application for a waste discharge permit from Los Angeles County and associated materials, including a laboratory analytical report for a waste discharge sample, a schematic flow diagram, and a cover letter (Shell, 1972b). The laboratory data indicate that trichloroethylene (TCE) was detected in the waste discharge sample. However, the letter, flow diagram, and notations on the laboratory report collectively indicate that at the time of sample collection, the waste stream from the laboratory was commingled with the effluent from the offsite Shell Oil Dominguez Refinery. The location where the effluent sample was collected is unclear, and it is therefore uncertain whether the detected TCE is associated with the ETC or the Dominguez Refinery. TCE was not listed as an ETC waste component in the memoranda described above, and there was no indication of TCE use in any other rubber plant documentation reviewed.

The preceding analysis and conclusions represent the best of the Respondents' knowledge to date. EPA has not yet finalized its analysis and conclusions, as EPA's investigation of chlorinated solvent use at the former plant site is still ongoing. EPA may issue future amendments or addenda to this RI report in the event that new information becomes available.

Other 500 Area Facilities

Little information is available regarding operations within the remaining sub-areas of the 500 area other than the facilities that are known to have been present. These facilities are identified below and their locations are indicated on Figure 11.

Sub-Area	Facilities
Water Treatment and Boilers/Steam Production	Chemical storage building, lime pit, treated water tank, boiler feed water tank, substation, storage house, "utility service/cooler box", "C5 slop storage tank, boiler house
Cooling Towers	Four cooling towers

2.3.3.6 Gas Storage Spheres and Railroad Loading Racks - 600 Area

The 600 area was used for product storage and transfer, and included a series of large, spherical containers for storage of pressurized butadiene and isoprene gases. Produced butadiene was stored in the aboveground pressure spheres prior to being transferred by pipeline to the copolymer plant. Railroad tracks and associated loading racks were present adjacent to Vermont Avenue. It is inferred that these facilities provided an additional means of transferring feedstock or finished product into or out of the butadiene plant.

Other facilities identified near the loading racks included a septic tank and nearby cesspool. Use of these facilities may have been limited to the early years of the plant, as some documentation indicates sanitary wastes were discharged to public sewer system.

2.3.3.7 Tank Farm - 700 Area

Aboveground tanks containing fuel oil, "lean oil", isobutylene dimer⁵ and/or toluene were located in the 700 area. "Slop oil" may also have been stored in the 700 area, although the storage location is not known. An additional tank was indicated as a "gas holder." Underground pipelines providing benzene and butadiene feedstock traversed the 700 area from east to west. The butadiene feedstock line turned north and entered the main processing area of the butadiene plant near the central portion of the 700 area, while the benzene pipeline continued westward and surfaced near the southeastern corner of the styrene plant. Further information regarding pipelines is provided in Section 2.3.5.

2.3.3.8 Future Development/Fabrication - 750 and 800 Areas

Little development was ever present within the 750 and 800 areas. A few construction-related buildings were present in the 800 area along with a power substation, and the area was

⁵ A dimer is a compound composed of two identical simpler molecules (monomers)

occasionally used for fabrication. No facilities were identified in the 750 area. Both areas were identified as being reserved for future development.

2.3.3.9 Plancor Wastes and Waste Handling

Wastes specific to the butadiene plancor included gases, which were discharged to the gas holder or burned in a flare, and aqueous solution wastes which were discharged to basins at the treatment area in the northeastern corner of the plancor. CAA wastes were collected in below-grade sewer lines and conveyed to the neutralizing basin. CAA wastewater was originally discharged to the Knox Street drain after treatment, but from 1951 onward, was discharged untreated to the sanitary sewer. Other process wastewater was collected in below-grade pipelines and transferred to the oil skimmer basin prior to discharge to the Knox Street drain.

Martin and Rostenbach (1953) reported that steam condensate from the dehydrogenation process was the major butadiene plancor waste requiring treatment. This waste was passed through a sand coalescer and gravity separator, where the separated oil was then returned to process. The effluent was discharged into the Knox Street drain. Wastes from the utilities, feed purification and gas recovery areas were discharged into two primary basins. Slop oil was skimmed off these basins and sent to the boiler house for use as fuel. The sludge that accumulated in the basins was removed once a year. Alkaline copper-bearing wastes were discharged directly into the Los Angeles County sewer system. Other process wastes were discharged after treatment into the Knox Street drain. Storm water runoff by-passed the gravity separators and passed through straw filters before entering the Knox Street drain.

2.3.4 Copolymer Plancor

The copolymer plancor, designated plancor 611, occupied approximately 82 acres north of the styrene plancor. Synthetic rubber was produced at the plancor by combining (polymerizing) styrene and butadiene with lesser amounts of other chemicals, including soap solutions and acid solutions. Other chemicals used in the rubber manufacturing process included cyclohexane, benzene, methanol, ajone DD (staining antioxidant), acosix (emulsifier), processing oils (naphthenic, aromatic and highly aromatic oils), and caustic solutions.

The rubber manufacturing process was divided into three parallel, east-west production lines within the 3000, 4000 and 5000-series areas respectively (Figure 11). Each production line included areas for feed formula preparation (3400, 4400, and 5400 areas), polymerization units (3300, 4300, and 5300 areas), unreacted monomer recovery (3200, 4200, and 5200 areas), and finishing and storage of final rubber products areas (3000, 4000, and 5000 areas).

Facilities and operations within each copolymer plancor area are further described below.

2.3.4.1 Tank Farm - 3500, 4500, and 5500 Areas

Tank farms were located in the 3500, 4500, and 5500 areas at the western edge of each rubber production line. Fresh and recycled butadiene was blended in a tank with excess butadiene piped back to the butadiene plant for purification. Styrene was similarly blended with fresh and recycled stocks and the excess recycled styrene sent back to the styrene plant for purification. According to the Rubber Producing Facilities Disposal Commission document (1953a), a total of 28 horizontal tanks were located within all of the tank farm areas, with capacities ranging from 8,000 to 30,000 gallons. Fifteen tanks, with capacities ranging from 25,000 to 30,000 gallons, contained butadiene, while four 30,000-gallon tanks held styrene. Of the remaining tanks, three held acids and caustics, two held methanol, and four held modifier solutions that regulated the plasticity of the rubber.

According to the deposition testimony of Mr. J. Koch (1989), the southern production line received most of the butadiene needed by tank car for approximately the first year of operation, when the butadiene plancor was not operating at full capacity. After the fall of 1944, approximately 95 percent of the butadiene used was piped in from the butadiene plancor, with the remainder arriving by tanker truck from other sources. With the exception of maintenance shutdown periods, the styrene plancor was the sole source of styrene, which was delivered by pipeline. Styrene was occasionally delivered by tanker car during the periods of styrene production shutdown.

Chemicals stored in the 3500 area included isopentane (location unknown) and cyclohexane, which were delivered by tanker car and tank trailer. Cyclohexane was also piped into the area from the styrene plancor (Shell drawing YT-12023) and stored in two of the vertical storage tanks (Shell drawing YT-5055-6). Drum deliveries of ajone DD (staining antioxidant) and acosix (emulsifier; location unknown) were stored in the 3500 area as well as D-100 (isoprene-isopentane; location unknown), D-101-104 (butadiene-isopentane; location unknown) and caustics (sodium hydroxide and potassium hydroxides). According to Shell drawings ZC-8512 and ZC-8514, benzene and butene were also used within the 3500 area. Other chemicals stored in the area included unspecified solvents, "oil feed", BLE (a condensation product of acetone and diphenylamine), non-staining oil, and dressinate (soap).

Styrene, butadiene, methanol, and SHS (dithionite solution), were generally stored in the 4500 areas. According to Shell drawing YT-5051-6, styrene was stored in the two eastern horizontal tanks of the main tank row. Sulfuric acid and methanol were stored within three horizontal tanks southwest of the pump house. Caustic was also stored in the 4500 area, although it is unclear in which tank.

Styrene, butadiene, and caustic solutions, were stored in the 5500 area. Styrene was stored in the easternmost vertical storage tank (Shell drawing YT-5066-4). Concentrated latex (uncoagulated rubber solutions) was also reportedly stored in the 5500 area, although no storage tanks with this label were identified on any maps reviewed.

2.3.4.2 Feed Formula Preparation - 3400, 4400, and 5400 Areas

Feed formula (monomer) preparation for the rubber manufacturing process occurred in the 3400, 4400, and 5400 areas. Both cold and hot polymerization processes were used. The cold process required preparation of four components. First, butadiene was pumped from the tank farm through a caustic scrubber (to remove inhibitor) and then mixed with a catalyst. Second, styrene was mixed with a mercaptan modifier, which regulated the plasticity of the polymer. Third, a soap solution was prepared by combining an emulsifier (rosin soap), a small amount of electrolyte (a sequestering agent, to lower the viscosity of the latex), and a dispersing agent into a tank of soft water. Fourth, an activator solution of unknown composition was prepared to activate the polymerization reaction. Hot polymerization required only three solutions: butadiene, styrene and soap. The soap solution contained only emulsifier, caustic and water. A catalyst solution was added separately.

Chemicals used and/or stored in the areas included staining and non-staining oils, emulsifier (acosix), antioxidant, ajone DD, BLE, soap solutions (aka dressinate), oleic acid, sodium dimethyldithiocarbamate (SDD; also referred to as shortstop), sodium polysulfide (Na_2S_x), fatty acid, and sulfuric acid. Aboveground tank capacities ranged from 14,000 to 50,000 gallons. Styrene was piped into the areas and used during the feed preparation process. Storage tanks at the south end of the 3400 area building contained oil emulsion, “make-up” and caustic. Additional tanks containing staining and non-staining oil may also have been present, although their exact location is unclear.

According to Shell drawing YT-5059-7, two underground storage tanks (USTs) were located south of the 4400 area building (not shown on Figure 11). One of the tanks contained shortstop solution. The contents of the other tank could not be determined from the drawing. According to a Shell MOJ, one of the USTs was used for storage of a sodium dimethyldithiocarbamate and sodium polysulfide solution (Shell, 1961). The MOJ proposed a new aboveground tank be used for shortstop storage and the underground tank be used for only sodium polysulfide storage.

2.3.4.3 Polymerization - 3300, 4300, 5300 Areas

Polymerization of the blended styrene-butadiene-soap solutions occurred in the 3300, 4300, and 5300 areas. Monomer feedstocks were combined to form latex in the reactor vessels, which were

operated batch-wise for hot-process rubber (120° F) and continuously for cold-process rubber (40° F). A shortstop solution was added to the reactors when conversion was reached, and the latex was then pumped to the recovery area. Reactor temperatures were maintained by circulation of water, brine, or methanol solutions circulated through internal heat exchangers and the reactor jackets. Heat was removed from the methanol coolant in a refrigeration unit, located in the 4700 area.

Chemicals used and/or stored in the polymerization areas included emulsions (extending oils, antioxidants), soap solutions, methanol, and latex (styrene and butadiene blend). Methanol was stored in aboveground tanks at the southeast corner of the building (Shell drawing YT-5058-9).

2.3.4.4 Recovery - 3200, 4200, and 5200 Areas

Recovery of unreacted butadiene, styrene, and polymer from the latex occurred in the 3200, 4200, and 5200 areas of the copolymer plant. Here the rubber process involved heating the latex with steam in the recovery unit, which flowed through stripping columns to recover unreacted butadiene and styrene, and then to latex storage tanks in the finishing area, where an antioxidant was added to prevent oxidation of the finished product. The separated butadiene and styrene were returned to the tank farm for reuse. Styrene produced during the stripping process was pumped to the 1400 area in the styrene plancor for purification. Certain types of polymers required addition of oil emulsions and/or carbon black slurry mixtures to the latex following stabilizer or antioxidant addition. Oil emulsions were prepared by mixing processing oil, an emulsifier, caustic soda, and water. Carbon black mixtures consisted of carbon black, caustic, a dispersing agent, and water. Some of the stripped latex was left uncoagulated and sold in liquid form.

Chemicals stored and/or used in the 3200 area included kerosene, sodium nitrate, styrene, butadiene and latex. For the 3200, 4200 and 5200 areas, kerosene was stored in one tank within the main building, and two additional tanks were located just north of the building. Two additional tanks contained an unspecified solvent, one inside the building and the other outside the building, on the south side. The exact location of the kerosene and solvent tanks is unknown.

Methanol and kerosene were used in the 4200 area. In the 5200 area, concentrated latex, butadiene and styrene were used. Styrene was recovered in each of these areas and stored in various tanks and vessels within the buildings. The primary effluent separators located in this area are described below under waste discharge.

2.3.4.5 Finishing - 3000, 4000 and 5000 Areas

The finishing process of synthetic rubber production occurred in the 3000, 4000, and 5000 areas. The blended latex from the recovery area was mixed with a brine solution (saturated rock salt with calcium and magnesium salts removed) in these areas and coagulated with dilute sulfuric acid. The resulting rubber crumb was fed from the coagulating tank to a soap conversion tank and then to a vibrating screen for dewatering. The rubber crumb was then recurred, filtered, shredded, dried, and baled. Bales were dusted with talc, packaged for shipment, and stored on pallets.

Chemicals stored and used in the 3000 area included emulsions (ajone DD, extending oil and antioxidants), oil, sulfuric acid, diesel, amine solution, brine solution, latex solution, silicon, BLE and carbon slurry. The aboveground tank west of the primary effluent separator was identified as an oil storage tank (Shell drawing YT-5051-7). The easternmost horizontal storage tank in the 3000 area was converted to diesel storage sometime in the 1960s (see Figure 11). A carbon black effluent basin was located south of the 3000 finishing area (Shell drawing YT-5050-5).

Chemicals stored and used in the 4000 area included concentrated and dilute sulfuric acid, brine solution, liquid alum, tallow fatty acid and latex waste storage. Chemicals in the 5000 area included PIP latex solution and waste latex.

2.3.4.6 Administration and Support - 6000 Area

The 6000 area included administration and support facilities, and was located around eastern, southern, and western perimeter of the plancor. Administrative facilities were located along the eastern side of the plancor, and included a guardhouse and hospital, two administration buildings, and a shipping building. The southern portion of the area consisted of largely open space. Facilities included a fire training area, contractors building, sheet metal/carpenter shop, locker and storeroom building. Waste facilities were located in the southwestern corner of the area, including a final effluent pit, and a flare stack. Several excavated areas collectively referred to as “pits and trenches” were additionally present. These facilities are further described below in Section 2.3.4.8.

A cooling tower and additional waste handling facilities were located in the northwestern corner of the plancor. According to Shell drawing YT-5067-8, a pump house was located immediately north of the cooling tower, a burn slab and flare stack further north, and a welding shop and cleaning/storage area to the northeast. An UST for gasoline was located west of and between the cooling tower and pump house. Further details regarding the burn slab, cleaning areas and UST were not available. Other facilities included a waste transfer station, and acid, caustic and “HCD” (composition unknown) storage tanks.

2.3.4.7 Miscellaneous - 3600, 3700, 3800, 4700, and 5700 Areas

Carbon black facilities were located in the 3600 area. Carbon black (soot) is an additive used to stain and increase the durability of rubber. A tank north of the 3600 building was used for carbon black storage and a slurry pit was present south of the building (Shell drawing YT-5043-8). "Replenishing agent" (composition unknown) tanks were present at the south end of the 3600 area.

Facilities within the 3700 area appear to have been limited to a large storage building. It is inferred that rubber product was stored in this area prior to shipping.

A variety of synthetic rubber types were blended, polymerized and recovered in reactors within the 3800 area. Benzene, butene, cyclohexane, methanol, oil, and Shell catalysts 118 and 607 (chemical equivalents unknown) were all used in the area (Shell drawings ZC-8512, ZC-8514, YT-12023 and YT-12019).

A refrigeration building was present in the 4700 Area. Four horizontal Freon storage tanks were located near the southeast corner of the building (exact location unknown; not shown on Figure 11).

The plancor laboratory and an adjacent garage/storage area were located in the 5700 area. The laboratory analyzed latex from the production areas as part of Quality Assurance/Quality Control (QA/QC) procedures. Waste latex was placed into 55-gallon drums and stored until a vacuum truck removed the latex (Shell, 1966b). An underground gasoline tank of unknown capacity was present east of the laboratory building. Isoprene and "C5 hydrocarbon disposal" storage tanks were present adjacent to the northwest corner of the laboratory building.

2.3.4.8 Wastes and Waste Handling

Information regarding wastes and handling was gleaned from various descriptive documents as well as facility maps. For this plancor in particular, there were numerous discrepancies between the various descriptions and maps with respect to wastewater handling, and the location of the facilities discussed was not always clear. For example, some descriptions indicate that copolymer plancor wastewater was treated using the primary skimmer basin in the styrene plancor, while other descriptions make no mention of this. The discrepancies are presumably due to changes in operations and facilities during the operational period of the plancor, although this cannot be verified on a case-by-case basis.

Wastewater

Wastewater handling facilities identified in the plancor include primary effluent separators #1 through #6 (Areas 5200, 4200, 3200, 5000, 4000 and 3000 areas, respectively), one or more secondary effluent separators (4400 area; other locations, if any, uncertain) and a final effluent pit in the southwestern portion of the 6000 area. Some descriptions indicate that the primary skimmer basin in the northern portion of the styrene plancor treated process wastewater from the plancor, but this is not believed to have been the case for most of the operational period of the plancor. Wastewater from the plancor ultimately received final treatment in the plant-wide treatment area in the northeast corner of the butadiene plancor before discharge to the Knox Street drain and Dominguez Channel.

Martin and Rostenbach (1953) reported that modifications and additions were made to the waste treatment system when the plants were reactivated in 1950. Regional separators were described as providing treatment for the combined wastes from the polymerization and recovery areas. Wastewater from these areas may have contained latex, polymer, and styrene. Latex was coagulated and removed in these separators. Regional separators that treated discharge from the process areas skimmed off the rubber crumbs and latex. Final separators received liquid from the regional separators, wastewater from the finishing area, tank farm drains and the pigment area wastes of soaps, antioxidants, modifiers and auxiliary chemicals. Floating materials were skimmed daily, and sludge was removed from the bottom of the final separators once a year. Clarified wastewater from this unit was discharged into the Knox Street drain. In 1952, an additional process separator was installed for clarification of liquid waste from carbon black masterbatch coagulation. This effluent was discharged into the final separator. An incinerator was also added that same year to burn precoagulum from strainers and piping without the emission of smoke.

It is inferred that only the primary effluent separators, which separated solid rubber fines from the waste stream, were operated at the beginning of the plant's operation. These concrete structures were set in the ground to a depth of approximately 5 to 7 feet, and were designed to catch both heavier and lighter waste elements. Floating rubber fines were the major waste element, and were skimmed by hand from the separators and drummed. The skimmed rubber fines were reprocessed and sold as an off-grade rubber product. Wastewater from each separator merged in an underground pipeline, passed under Vermont Avenue and out to the Dominguez Channel. The majority of the wastewater stream originated from the coagulation and filtration process effluent, with rubber fines and small amounts of serum (uncoagulated rubber) passed on to the separator. This system became plugged and was later replaced at an undetermined date, incorporating a discharge system that included all three production lines (Koch, 1989).

According to Shell drawing YT-5628, a separate primary effluent separator (PES) handled waste separation from each of four different areas: PES #5 received effluent from the open troughs in the 4000 finishing area; PES #6 received effluent from the open troughs in the 3000 finishing area; PES #2 received the effluent from the combined flow from underground pipes of the 4200 polymerization and 4300 recovery areas; and PES #3 received the combined flow from underground pipes of the 3200 polymerization and 3300 recovery areas (Figure 11). Discharge from these four primary separators combined with negligible flows from the tank farms and feed formula preparation (3300 and 4300 areas) was further processed in the secondary effluent separators. Discharge then flowed from the secondary separators in an open trough within the processing area, then east towards Vermont Avenue to the plant-wide treatment unit in the butadiene plancor.

A Shell MOJ describes the effluent discharge of the plancor as contributing the major flow to the combined rubber plant effluent (Shell, 1965). The plancor effluent included rubber fines, carbon black and occasionally aluminum hydroxide flocculate in suspension. Underground industrial waste lines transported wastes from the polymerization, recovery and finishing areas to the primary separators. The wastes were skimmed and settled, then passed on to the secondary separators where the effluent was further processed. The acid wastewaters associated with the black rubber process were controlled automatically, while caustic was manually added to acidic waters in other finishing areas of the plant. Underground industrial waste lines transported wastes from the tank farm and pump house areas to the secondary separators for processing. Effluent from the secondary separators crossed the plant eastward in an open flume to underground piping in the treatment plant at the northeast corner of the butadiene plancor.

Solid Waste

A waste transfer station was located near the western copolymer plancor boundary, west of the cooling tower. The transfer station was used as a solid waste holding area for periodic removal by a contractor. Shell drawing YT-11996-1 indicated that the transfer station consisted of an L-shaped concrete pit, and was 80 feet long by 32.5 feet wide by 5 feet deep. Additionally, solid latex wastes from the copolymer plant were generally disposed at a Class II landfill. During the winter (rainy) season the latex wastes were occasionally drained into temporary storage sumps at the styrene plancor. The location of the former sumps was not specified.

A series of excavations in the southwestern corner of the copolymer plancor, collectively referred to as the "pits and trenches area" are visible on some aerial photographs of the rubber plant. The pits and trenches do not appear on any available Shell maps and no other documentation describing their use or purpose is available.

Flare System

A flare stack was located in the southwest portion of the copolymer plancor. The flare system occasionally allowed the discharge of volatile flammable hydrocarbons into the plancor sewer system (Shell, 1966a). The flare served all the light hydrocarbon handling areas of the copolymer plancor, as well as the isopentane-cyclohexane processing areas (1400 area) and the vent from the toluene tank area (2400 area) in the styrene plancor. A drain line from the diked flare area extended underground to the final effluent pit that was interconnected to the secondary effluent separation in the processing area. The discharge from the final effluent pit flowed into the underground storm sewer, then east toward the Dominguez Channel. An effluent line was built to carry the discharge from the final effluent pit south across the copolymer plant/styrene plant boundary, then east to the treatment area in the northeast corner of the butadiene plancor.⁶

2.3.5 Rubber Plant Pipelines

The approximate locations of known underground pipelines at the former plant site are indicated by the dashed or dotted lines on Figure 11. The majority of below-grade lines and ditches at the former plant were water lines, process wastewater effluent lines, and storm sewers, as previously described above.

Hydrocarbon and chemical pipelines at the rubber plant were typically aboveground. The exceptions to this were the underground feedstock supply lines that entered the rubber plant near the southeast corner and continued westward along the south side of the LADWP utility corridor. At least eight inactive pipelines that carried feedstock from local refineries to the styrene and butadiene plancors are present in this corridor. Pipeline contents included butadiene, ethylene, C5 residuals, iso-amylene, toluol, isobutylene, natural gas, propane, propylene, and benzene. Some pipelines, including the benzene feedstock line, surfaced and continued aboveground into the styrene plancor production area from the southeast corner of the plancor. Other feedstock pipelines entered the butadiene plancor production area in the south-central portion of this plancor. Additionally, short sections of aboveground product pipelines within the plancors went underground where bypass of utility easements, railroad tracks, or right-of-ways was necessary.

Memoranda issued between 1972 and 1975 indicate that with the possible exception of a portion of the propane pipeline that remained in service, the plant product pipelines were abandoned. The pipelines were reported to have been flushed and filled with inhibited water.

In addition to the plant pipelines, numerous active pipelines unassociated with the rubber plant remain in two adjacent and parallel corridors along the southern boundary of the former plant site (Figure 13). These pipelines carry crude oil, partially refined oil, gasoline and other hydrocarbons

and have been operated by several oil and chemical companies over the past 50 years, as documented in previously issued documents (D&M, 1992b, HartCrowser, 1992). There is evidence of past releases from one or more of these pipelines, as discussed in the reports.

2.3.6 Rubber Plant Chemical Releases and Violations

Limited information is available regarding chemical releases and violations regarding the rubber plant. Most of the reliable documentation on this subject describes releases of oil, solids, or odors in the wastewater discharge to the Dominguez Channel. Martin and Rostenbach (1953) indicated that in the early years of plant operation, there were difficulties in maintaining waste stream suspended solids within acceptable limits. The pH of the combined waste stream from the three plancors differed from the individual plancor waste streams, causing aluminum and iron hydroxide to coagulate in the Knox Street drain and elevated solids content. Improved pH control was achieved in the early 1950s, reducing this problem. Occasional discharges of oil to the Dominguez Channel that exceeded permit limitations were also indicated in the Martin and Rostenbach paper. The problem originated largely from an oil-water emulsion waste generated at the butadiene plancor. The waste stream was treated using a sand bed to coalesce the oil and a gravity separator, but oil removal was not always completely successful.

Historical aerial photographs were reviewed to identify areas potentially impacted by hydrocarbons spills and leaks at the former plant site. While some useful information was gained through this, the technique was generally not found to be reliable for the following reasons:

- Available photographs of the rubber plant taken during its operational period are all black and white format, and sometimes of poor quality, especially for the photographs from the 1940s and 1950s;
- Pondered hydrocarbon compounds and contaminated surface water are typically indistinguishable from unimpacted surface water on aerial photographs;
- While aboveground facilities are easily identified by their regular shapes (lines, rectangles and circles) and usually elevated position relative to the ground surface, impacted soil is much more difficult to discern due its generally irregular shape and presence at or below ground surface.
- There are numerous possible explanations for areas where the land surface is relatively darker or lighter compared to the surrounding areas. Such areas are relatively common, are apparent on all the rubber plant photographs, and are not limited to area of the former plant site. While hydrocarbon releases and staining cannot always be ruled out as the cause, there are other explanations that are equally, if not more reasonable. These

⁶ Available maps indicate that underground pipelines from the final effluent pit in the copolymer plancor to the treatment facilities in the butadiene plancor were north of the copolymer-styrene plancor boundary. The origin of this discrepancy is unknown.

include the presence of low-lying vegetation, natural variations in the surface soil composition or moisture content, and rubber plant operations involving the spreading of non-impacted soil or water on the surface.

For the above reasons, RI investigations typically focused on the immediate vicinity of specific facilities where chemicals were known or suspected to be used, stored, or disposed. Areas of potential staining observed on aerial photographs were generally sampled only if they were immediately adjacent to chemical facilities that were otherwise targeted for investigation. The exception to this was a large area of darker soil in the southwest corner of the copolymer plancor. This dark area, or portions of it, appear in multiple aerial photographs taken between 1960 and 1972, some of which also show a corresponding concentric vehicle track pattern. The area is also adjacent to the carbon black storage facility, which is surrounded by a similar dark surface. Based on the above evidence, it was suspected that dark area may have been impacted by one or more releases of hydrocarbon-bearing materials; therefore, this area was sampled and evaluated (see Section 4.3.5).

Available details regarding other specific releases and violations are presented below.

- A large mass of oily rubber latex from a copolymer plancor tank that was being cleaned bypassed the treatment system and was deposited in the Dominguez Channel at the outfall of the discharge line. Shell was notified to correct the problem and increase the quality of the effluent (LADPW, 1965a).
- A brownish oil was observed in the discharge from the rubber plant to the Dominguez Channel, along with “excessive light floc.” The problem was tentatively attributed to insufficient maintenance at the treatment system straw filter. Additional straw filters were subsequently proposed (LADPW, 1965B).
- “Large bubbles and excessive foam” was observed at the outfall to the Dominguez Channel. The foaming was attributed to chemical reactions of spent caustic in the waste stream. The problem was corrected by running the effluent through straw filters (LADPW, 1967).
- Foam was observed at the Dominguez Channel outfall and was attributed to clearing of boiler blowdown that contained mud and iron oxide that bypassed the treatment facility (LADPW, 1968).
- The chemical oxygen demand (COD) for two samples of wastewater discharged to the Dominguez Channel was 5,250 and 5,590 pounds. These values exceeded the waste discharge requirement of 845 pounds. Foam was also observed at the discharge point. Shell responded in an August 1968 letter that they planned to divert the bulk of the dry weather flow from the channel to the sewer. The foam was attributed to a temporary

outage of an inhibitor pump, which was repaired the same day as the foam was observed (LARWQCB, 1968).

- The discharge to the Dominguez Channel was observed to be foamy and oily. This was attributed to accidental bypass of the treatment system by improper closing of a valve. The valve position was corrected to correct the problem.
- Mercury was detected in the discharge to the Dominguez Channel and attributed to the discarding of a mercury-containing reagent used for monitoring storm drain effluent quality (Shell, 1970b).
- The waste discharged to the Dominguez Channel was observed to be a reddish flow, and was attributed by Shell to waste water from condensate filters for two boiler plants. Shell proposed to eliminate the flow from the waste stream in the future to resolve the problem (LARWQCB, 1971).
- Hydrocarbon impacted soil was discovered (date unknown) during excavation in the isobutylene recovery/extractive distillation area (inferred to be in the 300 area of the butadiene plant). According to deposition testimony, brown-stained soil with a sulfurous odor was uncovered in the area. It was attributed to leakage of an underground wastewater pipeline, possibly involving caustic wastewater. The deposition testimony did not indicate the specific location of the contaminated soil (Donkle, 1990).

3.0 GEOLOGY AND HYDROGEOLOGY

The following summary of geologic and hydrogeologic conditions is based on information presented in the Groundwater RI (D&M, 1998a). The information was developed from data gathered as part of the previously completed hydrostratigraphic investigation, which included numerous continuously cored soil borings, cone penetrometer test (CPT) penetrations, and geophysical logging. The reader is referred to the Groundwater RI for a more detailed and comprehensive discussion of the hydrostratigraphic investigation and its results.

The primary purpose of the hydrostratigraphic investigation was to evaluate physical conditions and their influence on groundwater flow and dissolved contaminant migration. However, subsurface conditions also impact exposure pathways for vadose zone contaminants and the nature and distribution of NAPL, and are therefore relevant to this RI. For the purposes of this RI, the discussion of stratigraphy and physical conditions is therefore focused on the vadose zone and water table.

3.1 REGIONAL SETTING AND STRATIGRAPHY

As previously described in Section 1.2 above, the former plant site lies within the Torrance Plain physiographic area. The Newport-Inglewood structural zone, consisting of a northwest-southeast faulted anticlinal belt, transects the coastal plain and lies northeast of the former plant site. The rubber plant lies on the southwest limb of the Gardena syncline, which results in a dip of the local stratigraphic units of about 1° to the northeast.

The former plant site overlies the West Coast Groundwater Basin, a sub-basin of the Los Angeles Coastal Groundwater Basin (Figure 4). The West Coast basin is underlain by a sequence of middle Miocene through Holocene-age marine and continental sediments up to 13,000 feet thick. The near-surface deposits in the vicinity of the former plant site are part of the Lakewood Formation, which extends to a depth of approximately 200 feet bgs and predominantly consists of interbedded fine sand and mud (silt and finer sediment). The Lakewood Formation is interpreted to have been deposited in a coastal estuarine environment where fluvial and marine processes interact (CDWR, 1961). A schematic representation of the estuarine setting and associated depositional environments is presented in Figure 14.

The Lakewood Formation is divided into the Bellflower Aquitard and underlying Gage aquifer. The Bellflower Aquitard is further subdivided for the purposes of this RI based on the predominance of muddy or sandy lithotypes. These subunits include the following hydrostratigraphic units (HSUs): the Upper Bellflower Aquitard (UBF), the Middle Bellflower B

Sand (MBFB), the Middle Bellflower Mud (MBFM), the Middle Bellflower C sand (MBFC), and the Lower Bellflower Aquitard (LBF). The relationship between these HSUs and their relative thicknesses are illustrated in Table 5 and Figure 15. Representative cross sections showing the interpreted positions of the various HSUs at the former plant site are presented on Figures 16 and 17. These cross sections are based on soil boring logs and geophysical/CPT data that were previously presented in Appendices B, D, and E of the Groundwater RI Report (D&M, 1998a). Additional cross sections are available in the Groundwater RI.

For the purposes of this RI, the primary hydrostratigraphic units of concern are the UBF and MBFB, which cover the zone from the ground surface to the water table and the upper 25 feet of the saturated zone. These HSUs are described in more detail below.

3.1.1 Upper Bellflower Aquitard

The UBF is the uppermost HSU underlying the former plant site and ranges from 41 to 97 feet thick. Soil boring logs and CPT data completed during the RI show that the upper 20 to 30 feet of the UBF is a massive, fine sandy silt to silty sand. Beneath this is stratified mud and sand extending to the base of the UBF. Sand layers within the UBF typically range from one to 10 feet thick and tend to be discontinuous, while the finer grained muds are up to 30 feet thick and more continuous. A distinctive and laterally extensive fossiliferous layer is present in the UBF at depths ranging from 40 to 50 feet bgs.

3.1.2 Middle Bellflower

The MBF underlies the UBF and is a massive, light yellowish brown, fine to medium sand with local muddy zones. The average thickness of the MBF is approximately 65 feet. A laterally extensive mud layer is present within the MBF beneath the western portion of the former plant site, but thins rapidly to the east and is generally not identifiable in the central and eastern portions of the former plant site. Where present, the mud divides the MBFB into three members, identified from shallowest to deepest as the MBFB, the MBFM, and the MBFC. Where the mud is absent, the B and C sand units are merged and collectively referred to as the MBFB/C sand. Each member of the MBF is described in more detail below.

3.1.3 Middle Bellflower B Sand

The MBFB is generally olive-colored fine sand, with localized muddy layers and laminations. The sand can be massive, or include localized sedimentary structures including planar or cross-stratification, bioturbation, mud drapes, and mud rip-up clasts. These small-scale features can have a significant impact on the migration of dissolved plume contaminants and NAPL, as further discussed in the Groundwater RI report (D&M, 1998a).

Where the MBF mud is present, the MBFB has an average thickness of approximately 15 feet, a minimum observed thickness of 4 feet, and a maximum thickness of 34 feet. The elevation of the base of the MBFB ranges from -13 feet MSL in the southwest corner of the former plant site at soil boring XMW-22, to -91 feet MSL at boring SBL0034 in the northeast corner. Geophysical logs indicate relatively high resistivity, low gamma counts, and low spontaneous potential in MBFB sediments. The MBFB is defined on CPT logs by a very pronounced peak indicating a sharp increase in grain size at the top of the unit. The CPT probe often encountered refusal at the top of the MBFB.

3.1.4 Middle Bellflower Mud

The MBFM consists of a sequence of laminated silts and very fine sands that reach a maximum thickness of 25 feet in the southwestern portion of the former plant site and pinch out to the east. The average thickness of the mud is approximately seven feet. There is typically a gradational contact between the MBFB and MBFM, characterized by an increasing percentage of fine-grained sediments. Due to the inherently low permeability of fine-grained sediments relative to coarser grained sands, the mud is inferred to inhibit the vertical flow of groundwater and contaminants.

The elevation of the base of the MBFM ranges from -36 feet MSL at in the southwestern corner of the former plant site at boring XMW-165 to -103 feet MSL at boring SBL0027 in the north central portion. Geophysical logs indicate relatively low resistivity, high gamma counts, and high spontaneous potential in the MBFM.

3.1.5 Middle Bellflower C Sand

The MBFC sand is a thick body of fine to medium sand with local muddy layers and lenses. The transition from the MBFC to the MBFB is sharp to gradational, marking the transition from mud and muddy sand to predominantly clean, fine sand. The MBFC averages approximately 43 feet thick, but can vary from nine feet to 60 feet at the former plant site. A distinctive coarsening of the sand and layers of shell fragments in a sand matrix characterize the base of the unit. Sedimentary structures observed in the MBFC include large and small scale cross-stratifications, burrows, bioturbation, mud rip-ups, and mud drapes; however, much of the MBFC is massive.

The elevation of the base of the MBFC ranges from -72 feet in the southwest corner of the former plant site at boring SBL0020, to -129 feet MSL at boring SBL0028 in the northern portion. Geophysical logs indicate relatively high resistivity, low gamma counts, and low spontaneous potential in the MBFC. The base of the unit typically shows a pronounced high resistivity signature. Where the MBFM is absent, the merged MBFB/C is a virtually

uninterrupted sand unit with inferred greater hydraulic interconnection relative to areas where the mud is present.

3.2 PHYSICAL PROPERTIES

As part of the hydrostratigraphic investigation, selected soil samples were collected during the drilling and logging of exploratory soil borings for laboratory testing of physical soil properties. Representative samples of each HSU were collected from a broad geographic area to develop an understanding of soil physical properties and their variation within each unit. Physical properties analyzed for included air permeability, bulk density, effective porosity, grain density, hydraulic conductivity, liquid limit, moisture content, plastic index, plastic limit, porosity, specific gravity, total organic carbon, water saturation. Average values for each parameter and HSU are presented in Table 6. Grain size distribution was also analyzed for, and is summarized separately in Table 7. A comprehensive presentation of physical testing results is included in Appendix B. Data presented in Tables 6 and 7 are limited to samples collected from the UBF, MBFB and MBFM units, where the soil (vadose zone) contaminants, water table contaminants, and NAPL that are relevant to this RI occur. Dissolved contamination within deeper units is discussed within the previously issued Groundwater RI report (D&M, 1998a). The locations of the soil borings listed in Table 6 are shown on Figure 18.

3.3 WATER TABLE CONDITIONS

3.3.1 Historical Groundwater Levels

A hydrograph for selected wells in the vicinity of the former plant site that are screened in the water table, MBFB, MBFC, Gage, and Lynwood units is presented on Figure 19. These wells were selected for use on the hydrograph for their relatively long history of water level data, close proximity to each other, and representativeness of their respective hydrostratigraphic units. Based on the information presented, groundwater elevations from the water table through the Gage aquifer are inferred to have been steadily rising for approximately the last 30 years with an average rate of increase of approximately one foot per year. Although groundwater elevation data prior to 1956 are not available, the hydrograph further suggests that groundwater elevations were at least 15 to 20 feet lower than current conditions during much of the operational period of the rubber plant.

Additional evidence of long-term rising groundwater levels is provided by observed light non-aqueous phase liquid (LNAPL) conditions in the vicinity of well XMW-20. As described in Section 11.3, the LNAPL is submerged over an approximately 30-foot interval beneath the water table. This mode of occurrence is consistent with expected conditions after an LNAPL has

migrated through the vadose zone, intercepted the water table, and been influenced by a rising groundwater table. The fact that the LNAPL is observed over a 30-foot interval within the saturated zone indicates that groundwater has risen approximately at least 30 feet since the LNAPL first intercepted groundwater, and further supports the hydrograph data indicating a long term trend of rising groundwater.

Rising groundwater levels may be associated with adjudication of the West Coast Basin, which occurred in 1961. The adjudication date slightly precedes the observed onset of rising groundwater levels in 1965, which is attributable to the time necessary to implement groundwater pumping controls and to affect groundwater levels.

3.3.2 Current Conditions

Due in part to the slight structural dip of the subsurface HSUs toward the northeast, the groundwater table crosses the stratigraphic boundary between the UBF and MBFB along a demarcation line near the western boundary of the former plant site. The water table resides within the UBF to the east of the demarcation line, and within the MBFB to the west of the line, as shown on Figure 20. Groundwater conditions are therefore described with respect to the “water table zone” (UBF/MBFB).

The groundwater table at the former plant site is typically present at a depth of between 32 and 57 feet bgs based on 2004 groundwater elevation data, depending upon location. Groundwater elevation data and interpretive contours for the water table zone for 2000 and 2004 are presented on Figure 20. The 2000 and 2004 data are additionally presented in table format and further discussed in a previously issued Groundwater Monitoring Report and a Baseline Groundwater Sampling Report, respectively (URS, 2001d and 2005). The data show that the groundwater flow direction is toward the south-southwest over much of the former plant site, but a radial flow pattern associated with groundwater mounding is inferred in the vicinity of the Waste Pit Area and near the southeast corner of the former plant site. The cause of the mounding is inferred to be associated with a leaking irrigation pipeline in this area. According to representatives of the LADWP, this leak was recently repaired (LADWP, 2006).

An approximate average horizontal flow velocity for the water table zone is calculated using the following formula:

$$V = \frac{K(i)}{n}$$

3.0 GEOLOGY AND HYDROGEOLOGY

Where:

<u>Parameter</u>	<u>Description</u>	Rubber Plant Specific Values	
		<u>UBF</u>	<u>MBFB</u>
V =	velocity (feet/day)		
K =	hydraulic conductivity (feet/day)	3.0 feet/day	20 feet/day
I =	gradient (unitless); and	0.0025	0.0008
N =	effective porosity	0.15	0.15

Substituting values known to be typical of UBF conditions based on data specific to the former plant site results in a calculated velocity of 18.3 feet/yr. A similar calculation using parameter values typical of the MBFB results in a groundwater velocity of 36.5 feet/yr.

**4.0 INVESTIGATIVE APPROACH AND SCOPE
FOR EVALUATION OF SOIL AND NAPL**

4.1 INVESTIGATIVE APPROACH

The scope of the RI with respect to soil contamination and NAPL was shaped by a set of guiding principles based on known initial conditions. These principles were modified and refined as RI findings became known and are summarized below:

- Data were collected to adequately characterize surface exposure pathways and NAPL, and to evaluate remedial alternatives in areas impacted by rubber plant operations;
- Data collection was focused on areas where contaminants were known to be present or judged most likely to occur. These areas included rubber plant facility locations where chemicals were used, stored, transported, or disposed;
- Investigation proceeded outward from areas of known or suspected contamination to areas with unknown conditions;
- Disruption to current businesses was limited by minimizing intrusive sampling within and under buildings at the former plant site;
- Data was collected for a broad spectrum of contaminants but was primarily focused on VOCs, as initial findings suggested that these were the contaminants most commonly present and posing the greatest risk. Recently collected supplemental shallow soil data concentrated on PAHs to address data gaps identified by USEPA following review of the draft BRA (URS, 2001b).
- A dual “top-down” and “bottom-up” approach to data collection was emphasized and later integrated to identify groundwater contamination source areas and potential NAPL areas.

Further explanation of the above guidelines is provided below.

The RI/FS sampling strategy considered potential surface exposure pathways for chemicals associated with the rubber plant. Surface and shallow soil and shallow soil gas data were collected in areas where historical information indicated a potential for chemical releases to evaluate the ingestion, dermal contact, and particulate inhalation pathways. Data for the vapor inhalation pathway were collected through shallow and deep soil gas sampling, groundwater sampling, and workplace (indoor) air monitoring. Shallow soil and soil gas samples are those collected between 0 and 15 feet bgs, while deep soil and soil gas samples are those collected from depths in excess of 15 feet bgs.

4.0 INVESTIGATIVE APPROACH AND SCOPE FOR EVALUATION OF SOIL AND NAPL

The historical layout, operations and facility types within the former synthetic rubber plant complex have shaped the scope and approach of the RI. The former plant site layout was characterized by multiple areas of densely packed chemical storage and processing areas separated by large areas of open space and parking or administration facilities. The majority of the former plant site has been redeveloped with closely spaced commercial and industrial buildings since demolition of the plant. These factors resulted in RI/FS sampling locations being concentrated in accessible areas where the potential for contamination was judged to be highest, including areas of known contamination such as the MW-20 NAPL area and former facility locations where chemicals were stored, used, transported, or disposed. The map in Figure 21 superimposes historical plant facilities (as known from Shell maps and documents, historical aerial photographs, deposition testimony, and technical papers) and current surface features (buildings, roads, etc). The map was created using photogrammetric techniques and stereo pairs of aerial photographs and provided a basis for planning of all RI sampling locations.

While the location of former facilities is well documented for the rubber plant, many of the facilities of interest were found to lie partially or entirely within the footprint of existing, active business buildings. Due to the difficulty in accessing these areas and the associated disruption to the businesses, subsurface sampling beneath existing buildings was avoided. Where contamination was suspected to underlie a building, sampling was completed at appropriate areas immediately adjacent to the building and the building was targeted for indoor air monitoring. Water table data for the area was also evaluated to provide an indication of whether significant soil contamination was present.

Samples were analyzed for a broad spectrum of chemicals of potential concern by various methods, as listed below:

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Sample Medium	Analyte Class	Analytical Method
Soil Gas	VOCs	Field GC
		TO-14
Soil	VOCs	8010
		8020
		8240
		8260
	SVOCs/PAHs	8270
		8270C SIM
	Pest./PCBs	8080
		8081
		8082
	Metals	6010
		6020
		7060
		7470
		7471A
	Cyanide	335.2
9010		
pH	9045C	
Indoor Air	VOCs	HSA1501
		TO-14
Groundwater ⁷	VOCs	601
		602
		8010
		8015
		8020
		8021
		8240
		8260

Early data for groundwater and other media at the former plant site indicated that elevated levels of VOCs, particularly benzene, were distributed across a greater area and at more significant concentrations than for other chemicals tested for. Given this finding and the relative toxicity of benzene and related compounds, VOCs were judged to be the primary risk-driving compounds and chemicals of concern. The RI/FS therefore subsequently focused on former plant site facility locations where VOCs were known to have been stored, transported, or used in plant process areas. However, following review of the draft BRA, regulatory agency comments indicated a concern that data for some contaminants, particularly PAHs, was insufficient and represented a data gap. As a result, an addendum to the RI scope was developed and completed that focused on facilities where the potential presence of PAHs was greatest, as well as additional facilities that

⁷ Groundwater data for non-VOC compounds are presented in the Groundwater RI Report (D&M, 1998a)

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may have been associated with VOCs. While VOCs are still considered to be the primary contaminants at the former plant site, the additional data have resolved the perceived data gap and allow for a more robust and thorough final risk assessment.

Multiple lines of evidence were used to identify and evaluate areas where past chemical releases may have contributed to soil and groundwater contamination. The search for such areas proceeded in both a “top-down” and “bottom-up” fashion. The top-down process started with the historical rubber plant documentation, which led to shallow soil and/or soil gas sampling being focused in former process, pipeline, and chemical storage/disposal areas. Where elevated chemical concentrations were detected, downgradient groundwater sampling was completed, as well as additional step-out sampling in the vadose zone.

The “bottom-up” process started with an independent water table plume delineation program that included sampling along multiple transects across the former plant site and critical portions of its perimeter. The detection of elevated concentrations of dissolved contaminants in groundwater led to additional groundwater, soil or soil gas sampling in upgradient areas that could be sources for the groundwater plume.

Using this combined top-down and bottom-up approach, groundwater contamination source areas and potential NAPL areas were identified. Given that contamination associated with rubber plant operations has had approximately 30 to 60 years to impact groundwater, application of the top-down/bottom-up approach provides confidence that the most significant areas of soil and groundwater contamination at the former plant site have been identified and evaluated.

4.2 EXCLUSIONS

The Waste Pit Area of the former plant site was investigated as a separate operable unit, distinct from the soil and NAPL operable unit. A separate RI/FS report (Dames & Moore, 1996b), as well as a ROD documenting the USEPA-selected remedial technique for the Waste Pit Area (USEPA, 1997) have been previously completed. Data, findings and conclusions regarding the Waste Pit Area are therefore excluded from the discussions below, except where specifically referenced.

An RI, FS and ROD have also been previously issued for the Dual Site Groundwater Operable Unit, Montrose Chemical and Del Amo Superfund Sites (D&M, 1998a; CH2M Hill, 1998; USEPA, 1999a). Groundwater contaminant conditions are therefore not described in this report, with the exception of dissolved VOC concentrations within the water table zone. Water table VOC conditions are included in this report due to the potential for vapor migration through the

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vadose zone to the surface and the associated human health risk. Water table groundwater data are also used in this report as an aid to evaluation of the potential presence of NAPL and/or groundwater contamination source areas.

4.3 INVESTIGATION ELEMENTS

A chronological overview of the various RI elements and their association with other investigations is presented in Figure 22. Many of the early RI elements were completed as part of an intensive period of initial investigations completed in 1992 and 1993 in accordance with the MW-20 Focused Investigation and RI Work Plans (D&M, 1992 and 1993c,e). Although the RI data are representative of conditions at the time the sampling was completed, the data are conservative, since contaminants typically degrade through time.

The early RI investigation elements were commonly focused on evaluation of conditions within specific geographic areas, facilities, or groups of facilities, which are shown on Figure 23. A brief description of each investigative element associated with evaluation of the nature and distribution of contaminants is presented below to aid the reader in understanding the rationale for the selected sampling locations and analytical program. The scope for each investigative element is summarized in Table 8, and the text below refers the reader to previous documents for further details, as applicable. Discussion of investigation results is deferred until later sections of this report, and is primarily organized by sample media rather than by the investigative elements described below to promote an understanding of contaminant conditions across the entire former plant site.

4.3.1 MW-20 Focused Investigation

The MW-20 Focused Investigation was completed in 1992 to evaluate the nature, extent and source of the LNAPL that was known to be present near the western boundary of the former plant site, at the northern end of the former styrene plant tank farm area (Figure 23). The investigation included completion of numerous soil borings, temporary well points and shallow and deep soil gas points. The mode of occurrence and lateral and vertical extent of the NAPL were evaluated based on visual inspection of soil samples from monitoring well and soil borings, and from inspection of fluid samples from temporary well points and monitoring wells. A hydrophobic, hydrocarbon soluble dye (Sudan Red) and “jar testing” observations were used as aids in identification of NAPL. Details regarding the scope and findings of the investigation are provided within Dames & Moore’s March 5, 1993 report entitled “Focused Investigation, Nature and Extent of Non-Aqueous Phase Liquid, Monitoring Well MW-20” (D&M, 1993b).

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4.3.2 MW-20 Source Area Investigation

The MW-20 Source Area Investigation was a continuation of the above-described focused investigation, with objectives of evaluating the likely source of the NAPL and the extent of any associated vadose zone contamination. The investigation was undertaken in 1993, and included seven additional soil borings and collection of shallow soil gas samples at numerous locations. Soil and soil gas samples were analyzed for VOCs and the deeper soil borings were additionally evaluated with respect to the potential presence of NAPL.

4.3.3 MW-20 Pilot Program

The MW-20 Pilot Program field work was conducted from 1994-1997 to evaluate the efficacy of LNAPL removal through hydraulic extraction. Initial NAPL conditions were established in a portion of the known LNAPL area through multiple soil borings and use of various NAPL identification techniques. A six-month period of groundwater pumping was then completed in an effort to increase the groundwater gradient and induce NAPL trapped in pore spaces to flow into extraction wells. Additional soil borings were then completed immediately adjacent to the original borings to allow comparison of pre-and post-pumping NAPL conditions.

The MW-20 Pilot Program and its findings are more relevant to the Soil and NAPL FS report (in progress) than this RI report. However, information regarding LNAPL identification, modes of occurrence as well as NAPL saturation data generated from the investigation is included in this report. A comprehensive presentation of findings from the MW-20 Pilot Program is presented in the MW-20 Pilot Program Summary Report (URS, 2003a).

4.3.4 Southwest Styrene Plancor Storage Area Investigation

Historical documentation indicates that drums, various equipment, and unused storage tanks were formerly present near the southwest corner of the styrene plancor (Figure 23). Two soil borings and multiple shallow soil gas sampling locations were completed in this area in 1993. Soil samples were analyzed for a broad range of contaminants, including VOCs, semi-volatile organic compounds (SVOCs), metals, pesticides, PCBs, and cyanide. The soil gas samples were analyzed for VOCs.

4.3.5 Southern Copolymer Plancor Stained Area Investigation

While the southern portion of the former copolymer plancor was largely vacant during the operational history of the synthetic rubber plant, pervasive staining in the area was observed on many aerial photographs. Twelve soil borings were completed in this area in 1993, with at least one sample from each boring analyzed for VOCs and SVOCs. For some analyses, the samples were composited from multiple borings. Completed analyses included VOCs, SVOCs, pesticides/PCBs, metals, and cyanide.

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4.3.6 Utility Tanks Investigation

The utility tanks investigation was completed in 1993 to evaluate subsurface conditions at former aboveground “utility” tanks at the southern end of the tank farm in the styrene plancor (Figure 23). One soil boring and numerous shallow soil gas sampling locations were completed in this area to obtain VOC and SVOC data. Subsequent to the sampling at the utility tanks, access to the area has been limited by a large concrete slab that was placed by the local business and used for storage of large steel stock.

4.3.7 Surface Soil Investigation

Significant undeveloped and unpaved areas were present along the southern margin of the styrene plancor, in the southern portion of the butadiene plancor, and in the northwest corner of the copolymer plancor at the time the RI was initiated (Figure 23). These areas were targeted for investigation based on the potentially greater likelihood for contaminant exposures associated with exposed soil in uncontrolled areas. Multiple surface soil samples (0-1 foot bgs) were collected in 1993 within each of the areas and analyzed for the broad-spectrum contaminant list. Composite samples were prepared and analyzed in some cases. Since completion of the surface soil investigation, the areas in the southern butadiene plancor and northwestern copolymer plancor have been developed and no longer contain large areas of exposed soil.

4.3.8 Shallow Soil Gas Investigation

“Shallow soil gas investigation” is intended to refer to the totality of shallow soil gas sampling locations and results rather than a single event investigation specific to a rubber plant area or facility. Use of the term has proliferated in various RI documents because of the focus on VOC contamination and use of shallow soil gas sampling as the primary method of evaluation at former facilities where VOCs were used, stored, transported, or disposed. For these reasons, there is significant overlap between the soil gas investigation and the other, geographically oriented investigations described above, which also included or exclusively relied on shallow soil gas sampling.

Shallow soil gas samples are those collected at depths of 15 feet bgs or less. Shallow soil gas samples were collected from 848 locations within the former plant site, excluding the Waste Pit Area, between 1992 and 1995. All samples were analyzed for VOCs in the field using a gas chromatograph-equipped mobile laboratory. Additional summa canister samples were collected at approximately 10% of the sampling locations and analyzed for VOCs by a fixed laboratory using USEPA Method TO-14. The purpose of the TO-14 analyses was to confirm the mobile laboratory results and allow for their use in the BRA, in accordance with the RI Work Plan (D&M, 1993a).

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Shallow soil gas sampling results have previously been presented within the MW-20 Focused Investigation report (D&M, 1993b), and a technical memorandum addressing the former plant site pipeline and trench transmission system (D&M, 1995d). This Soil and NAPL RI Report is the first document to comprehensively present all shallow soil gas data, which are discussed in Section 6.

4.3.9 1993 Addendum Investigation

The 1993 Addendum Investigation refers to a scope of work completed in accordance with a March 22, 1993 work plan (D&M, 1993c) that was intended as a supplement to the preceding RI/FS Study Work Plan (D&M, 1993a). The 1993 Addendum Investigation involved sampling of additional VOC-related facilities that was judged necessary based on initial findings from the RI and, like the soil gas investigation, was not focused on any specific geographic area. Numerous former VOC-related facilities were targeted for shallow soil gas sampling. The investigation also included testing for dissolved VOCs in the water table zone at temporary well points downgradient from suspected VOC sources or surrounding areas of known contamination. The investigation results were incorporated into later reports, but were not presented as an independent data set. The results are similarly incorporated into this report, within Sections 6 through 10.

4.3.10 2003 Addendum Investigation

The 2003 Addendum Investigation is the most recently completed portion of the RI, and is based on the scope of work described within the December 4, 2002 Work Plan (URS, 2002) and subsequent revision letters. The primary purpose of the investigation was to address RI data gaps identified during regulatory agency review of the Draft BRA (URS, 2001b). The investigation focused on collection of additional VOC and PAH data at former facility locations where these contaminants were likely to be present and/or where risk assessment evaluations indicated there was an unacceptable level of uncertainty with respect to exposure point concentrations.

The 2003 Addendum Investigation additionally included collection of a lesser number of soil samples for metals and pesticides/polychlorinated biphenyl (PCB) analyses. Most of the metals sampling was along the footprints of former cooling towers, where testing was limited to total chromium and hexavalent chromium analyses. The pesticide/PCB analyses were completed for samples collected from former machine shops, transformer locations and disposal facilities.

Soil rather than soil gas samples were collected for the 2003 Addendum Investigation to allow for a variety of analyses and cost efficiency. Sample collection was limited to the upper 15 feet of soil, where contaminant exposure via direct contact with soil would be most likely to occur.

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Sampling was further limited to accessible locations outside of existing buildings to avoid disruption to business operations.

A total of 165 shallow soil borings were completed as part of the 2003 Addendum Investigation. Soil boring logs for the investigation have not been presented in previous reports due to their relatively recent completion, and are therefore included in Appendix C.

Laboratory analyses for VOCs, PAHs, metals, pesticides and PCBs, and pH were completed at selected shallow soil borings based on historical information regarding the former plant site facilities and chemicals known to have been used or stored therein. A summary of the sampling and analytical plan for the investigation is presented in Table 9. In addition to the originally planned borings, numerous “step-out” borings were completed and sampled based on field evidence indicating the potential presence of significant contamination, as well as laboratory data indicating contaminant concentrations in excess of screening criteria. Further discussion of the screening criteria is presented in Section 5, and details regarding the scope and procedures for the 2003 Addendum Investigation are provided within the December 4, 2002 Work Plan (URS, 2002). A discussion of results specific to the 2003 Addendum Investigation soil samples is presented in Section 12 of this document. Results from the addendum soil samples are also included in the comprehensive discussion of RI shallow soil samples in Section 7.

4.3.11 Pipeline and Trench Transmission System Investigation

A network of subsurface pipelines and trenches used primarily for surface drainage and plant wastewater was present at the former plant site as indicated by the dotted green lines on Figure 23. A single liquid VOC feedstock pipeline for benzene was also present in the southern portion of the butadiene plant. The pipeline and trench transmission system investigation field work was completed in 1994 and 1995 and consisted of shallow soil gas sampling where there was a potential for VOC solutions to have been transported in the transmission system. The investigation was limited to subsurface transmission lines, as these were judged to have the greatest potential for unobserved chemical releases and associated areas of subsurface contamination.

Pipeline and trench sections that were within or adjacent to current building locations, and/or that were known to contain concentrated VOC solutions, were preferentially sampled over other sections based on a perceived greater potential for exposure and/or impacts to groundwater. The entire length of these “priority” pipeline sections was sampled using 25-foot sample spacing. A statistically based sampling program of 100 sampling points was utilized for the remaining, lower priority pipeline sections. The investigation findings are detailed within a Technical

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Memorandum (D&M, 1995d) and the data are incorporated into this report along with soil gas data from other investigations.

4.3.12 Indoor Air Monitoring

Indoor air data were generated as part of the Workplace Air Monitoring (WAM) program completed between 1993 and 1995 to evaluate the potential for worker exposure to VOCs. The program was initiated in response to concerns that some existing buildings were situated over possible contamination, resulting in a potential for exposure through vapor migration. Indoor air sampling was completed at 13 buildings that overlie or are immediately adjacent to areas where vadose zone VOC contamination was either known or suspected to be present. Outdoor air data were additionally collected at each building to establish background conditions. Comprehensive discussion of the scope and results of the investigation are presented in the Workplace Air Monitoring Program Report (URS, 2001c) and are additionally summarized in Section 9 of this report.

4.3.13 NAPL Screening Investigation

While the most extensive investigation of NAPL was focused on the MW-20 area, detected water table VOC concentrations suggested the potential for NAPL at additional areas. Three such areas were selected for additional investigation to: (1) characterize physical conditions and the nature of NAPL that may be present; and (2) evaluate whether conclusions regarding the effectiveness of NAPL remediation technologies at the MW-20 area can appropriately be applied to other areas of the former plant site where NAPL may be present. The three areas selected for NAPL screening evaluation are referred to as Source Areas 6, 11, and 12, and are located as indicated on Figure 23. The potential presence and nature of NAPL in these areas was evaluated in 1997 through the following methods:

- CPT-assisted collection and observation of fluid samples from the saturated zone;
- Use of the Rapid Optical Screening Tool (ROST) technology;
- Screening of soil core in the laboratory using ultraviolet (UV) light and “jar testing;”
- Laboratory testing for hydrocarbon saturation; and
- Laboratory testing of soil samples for VOCs and SVOCs to evaluate the probable NAPL composition (NAPL samples were not possible to collect or were of insufficient volume to permit direct analysis).

Additional physical testing of soil core samples was also completed for the investigation. Results of the NAPL screening investigation were presented in the Summary of NAPL Screening Investigations, Source Areas 6, 11 and 12 (D&M, 1998b) and are summarized in Section 11 of this document.

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4.3.14 Groundwater Investigation

For the purposes of this report, discussion of the groundwater investigation is limited to the water table zone and data from the 2000 groundwater monitoring event. Groundwater data are relevant to the Soil and NAPL RI with respect to the potential for migration of VOC vapor from the water table to the surface and for evaluating the potential presence of NAPL and/or groundwater contamination source areas.

Investigation of groundwater contamination has been an ongoing process since the initiation of the RI. Areas of known groundwater contamination prior to initiation of the RI included the MW-20 NAPL area and the Waste Pit Area. From these areas of known contamination, initial fieldwork was devoted toward establishing the lateral extent of contamination through sampling along transects approximately parallel and perpendicular to groundwater flow. Additional sampling points were completed along upgradient portions of the former plant site perimeter to evaluate conditions where groundwater entered the rubber plant. Following evaluation of initial RI data, groundwater sampling points were completed immediately downgradient of former plant site facility locations where vadose zone data indicated VOC releases were likely. These locations were part of the “top-down” process used to identify groundwater contamination source areas, as previously described in Section 4.1 above.

Water table data are available from temporary well points and numerous monitoring wells within the former plant site. Groundwater data is restricted to a single sampling event for the temporary well point, but multiple time-series sampling events have occurred for the monitoring wells. Groundwater monitoring was completed first on a quarterly basis starting in February 1994, and then annually through 2000. Monitoring data are available for up to 14 different monitoring events, depending upon the well of interest and its date of completion.

More comprehensive discussions of groundwater conditions are available in the 2000 groundwater monitoring report for the former plant site (URS, 2001a) and the Groundwater RI (D&M, 1998a). Additional groundwater characterization and monitoring events were conducted starting in January 2004 in support of groundwater remedial design work. Results of these monitoring events will be presented in future reports pending receipt of results and data evaluation.

4.3.15 Non-RI Data

A substantial volume of laboratory analytical data for the former plant site has been generated outside of the Soil and NAPL RI. These data, collectively referred to as the “non-RI data”, typically originate from investigations conducted on behalf of individual property owners, and

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were completed by numerous investigators, including D&M and other consulting firms. In some cases, the data have been independently submitted to USEPA.

Available non-RI data was included in the RI database provided it met specific quality assurance/quality control criteria. These criteria were based on a subset of the principles presented in the USEPA National Functional Guidelines (USEPA, 1999b) as well as supporting information, as described in Appendix A of the BRA (Geosyntec & URS, 2006). Data for 112 non-RI/FS samples were incorporated into the RI database. Sources from which accepted non-RI data originated are as follows:

- Geraghty & Miller, 1998 (B- and S-series soil borings, northwest corner of former plant site)
- Hydrosearch, 1991 (SG-series soil gas samples and XDWP-series soil borings, southeast corner of former site)
- Law/Crandall, 1996 (GP-series soil borings, central butadiene plancor)
- Secor, 1997 (GP-series soil borings, southeast corner of the former plant site)
- D&M, 1997d (GPL-series borings, northern styrene plancor)

Details regarding the above references are provided in Section 15.

5.0 DATA PRESENTATION FORMAT AND EVALUATION CRITERIA

The data for the various sample media and chemical parameters are summarized in Sections 6 through 10 below. A comprehensive database with results for all analyses completed at each sampling location is presented as an electronic text file on the attached compact disk in Appendix B, and can be accessed using any word processing or spreadsheet software. The data are also presented in summary tables indicating detected compound concentrations and salient statistics for each sample medium and compound class (VOCs, SVOCs/PAHs, etc.), and on figures showing sampling locations for the various analyses. Data are additionally summarized in a parcel-by-parcel format in Appendix D.

Discussion of findings is primarily organized by sample medium (soil gas, soil, indoor air, groundwater) and contaminant type (VOCs, SVOCs/PAHs, pesticides/PCBs, etc) rather than by the specific investigative element (see Section 4.3 above) or geographic area to promote an understanding of conditions across the entire former plant site. An assessment of the data quality is presented in Appendix E.

The data are evaluated with respect to a range of screening criteria specific to the sample medium and data type, as discussed below.

5.1 SHALLOW AND DEEP SOIL GAS

There are no widely accepted regulatory agency criteria by which soil gas data can be directly evaluated. Screening criteria used in the RI were limited to “threshold levels” and a 5 parts per million by volume (ppmv) field criterion that were applied only to shallow soil gas data.

The “threshold levels” screening criteria indicated the compound concentrations at which a potential for unacceptable exposure may have existed within an overlying or adjacent building (within approximately 25 feet). Threshold values were derived based on modeling of radon gas transport (Little et al, 1992; Shell, 1995) and were accepted by USEPA for application during the RI. Exceedance of the threshold criteria triggered subsequent efforts to complete indoor air monitoring at adjacent buildings, as described in Section 9. Threshold criteria were only applicable to shallow soil gas since deep soil gas sampling depths were 47 feet bgs or more, and were not judged representative of near-surface conditions.

VOCs were also considered to be elevated at shallow soil gas sampling locations where one or more VOC concentrations exceeded the 5 ppmv field screening criterion. Exceedance of this screening criterion triggered collection of additional step-out samples and further evaluation of

5.0 DATA PRESENTATION FORMAT AND EVALUATION CRITERIA

the area as a potential groundwater contamination source area until the VOC concentrations decreased from the original sampling locations by 50% or more.

The 5 ppmv screening criterion was selected as a relatively low concentration and took into account conditions associated with known groundwater contamination source areas. Further discussion regarding the criteria for identification of groundwater contamination source areas is presented in Section 12. This screening value was previously identified in RI work plans (e.g.: D&M, 1994b). The 5 ppmv screening value is not a regulatory agency promulgated value and does not correspond with any specific health risk.

The 5 ppmv “step-out” criterion was not applied to deep soil gas samples since these samples were all collected within a limited area for potential use in delineating NAPL. VOC concentrations were highly elevated (far above 5 ppmv) at each of the 12 deep soil gas sampling locations (see Section 6.2) and delineation of NAPL was primarily achieved through other techniques, as detailed in Section 11.

5.2 SURFACE, SHALLOW AND DEEP SOIL

Soil data were evaluated with respect to USEPA Region IX residential or industrial preliminary remediation goals (PRGs). While PRGs are risk-based screening concentrations, they do not take into account the presence of background levels of contaminants and other conditions specific to the former plant site. For this reason, PRGs are not intended as enforceable standards or as an indication that there is a significant health risk. PRGs are preliminary screening standards to determine whether additional evaluation is warranted through collection of additional data and/or completion of a risk assessment, where the health risks are calculated with the various factors specific to the former plant site taken into consideration. Residential PRG values are more conservative (lower) than industrial PRG values, reflecting the potential for greater durations of exposure and the presence of children. The PRG screening criteria cited below for each analyte class were used both as a trigger for completion of additional “step-out” sampling locations and as a cut-off point for highlighting sampling locations with concentrations of potential concern.

All VOC and pesticide/PCB soil data were evaluated with respect to residential PRGs. Industrial rather than residential PRGs were used as the screening criteria for PAHs, as agreed to by USEPA, due to the ubiquitous background presence of these combustion products in shallow soil, likely associated with the nearby freeways. The PRG for an appropriate surrogate compound was used for those PAH analytes with no published PRG. PAHs for which a surrogate PRG was used include acenaphthylene, benzo(g,h,i)perylene, 2-methylnaphthalene and

5.0 DATA PRESENTATION FORMAT AND EVALUATION CRITERIA

phenanthrene. While rarely analyzed for or detected, SVOC compounds other than PAHs were evaluated with respect to residential PRGs.

Residential PRG values were typically used as the screening criteria for metals in shallow soil. Unlike most organic contaminants, metals are naturally occurring and expected to be detected in samples at background levels. Thus, their detection alone does not indicate a contaminant release. Furthermore, naturally occurring background levels can exceed PRG screening criteria, as is the case for both arsenic and iron at the former plant site. Concentrations of up to 10 milligram per kilogram (mg/kg) for arsenic and 48,000 mg/kg for iron were considered to be background at the former plant site based on statistical analysis of shallow soil data, following methods presented in the BRA (Geosyntec & URS, 2006). The residential PRG values for these metals (0.39 and 23,000 mg/kg, respectively) are significantly less than the calculated background concentrations. For this reason, the cited background concentrations were used in place of residential PRGs for arsenic and iron. USEPA approved the use of non-PRG screening criteria for arsenic and iron during a March 12, 2003 meeting (USEPA, 2003)..

5.3 INDOOR AIR

Indoor air data from selected buildings at the former plant site were previously presented in the WAM report (URS, 2001c). Evaluation of the indoor air data in the report was limited to comparison with compound-specific Permissible Exposure Limits (PELs) established by the California Occupational Safety & Health Administration (CAL-OSHA), and PELs modified by using an additional safety factor of 20 (i.e., PELs divided by 20). PELs are enforceable workplace standards under federal and state law.

For this RI report, the WAM data are additionally compared to USEPA-derived PRG values for ambient air. Ambient air PRG values are typically much more conservative (lower) than PELs.

5.4 GROUNDWATER

Groundwater data presented in this report are limited to VOC concentrations in the water table zone. These data are evaluated in the RI Report with respect to primary drinking water maximum contaminant levels mandated by the State of California (Cal MCLs). MCL criteria are based on both health risks and feasibility of treatment.

5.0 DATA PRESENTATION FORMAT AND EVALUATION CRITERIA

In summary, the Soil and NAPL RI data were evaluated with respect to the following criteria:

Sample Medium	Analyte Class	Screening Criteria
Shallow soil gas	VOCs	“Threshold values” and 5 ppmv step-out criterion
Deep soil gas	VOCs	None
Surface, shallow, and deep soil	VOCs	Residential PRGs
	PAHs	Industrial PRGs and surrogate compound industrial PRGs for those PAHs without PRGs
	Non-PAH SVOCs	Residential PRGs
	Pesticides/PCBs	Residential PRGs
	Metals	Background for arsenic and iron, and residential PRGs for all others
Indoor air	VOCs	PELs, PEL/20, and ambient air PRGs
Groundwater	VOCs	Cal MCLs

The analyte-specific screening criteria for each sample media are presented in Table 10.

6.0 SOIL GAS DATA

6.1 SHALLOW SOIL GAS

6.1.1 Overview

Shallow soil gas samples were collected at 848 locations where VOCs were stored, transported, or disposed during the operational history of the synthetic rubber plant. The shallow soil gas data were collected between 1992 and 1995. Comprehensive shallow soil gas results are presented in electronic text file format on the compact disk in Appendix B. Figure 24 shows each shallow soil gas sampling location, and detected VOC concentrations for each location are summarized in Table 11. The frequency of detection and maximum detected concentration for each VOC are summarized in Table 12. As indicated in the table, benzene, toluene, ethylbenzene and xylenes (BTEX), styrene, and cyclohexane are the compounds most often detected at higher concentrations (above 5 ppmv). These compounds are all known to be associated with the former plant site.

1,3-Butadiene is also known to have been associated with the rubber plant, but soil gas investigations did not normally include it as a target analyte since this compound is a gas at standard conditions and would have rapidly volatilized to the atmosphere upon release. Results for this compound are limited to six samples, all of which are non-detect.

6.1.2 Threshold Value Exceedances

As explained in Section 5 above, shallow soil gas data were compared to threshold screening criteria to determine when indoor air monitoring was appropriate. One or more VOC concentrations exceeded their respective threshold values at 55 sampling locations, as shown on Figure 25. VOCs detected at concentrations in excess of their screening criteria included benzene (54 locations), ethylbenzene (2), styrene (1), and 1,2-dibromomethane (1). Threshold value exceedances occurred in the following areas of the former plant site:

- Adjacent to former VOC storage tanks in the tank farm area of the styrene plancor (benzene, ethylbenzene and styrene);
- In the vicinity of a styrene finishing/benzene purification unit in the styrene plancor (1,2-dibromomethane);
- Near a former waste water pipeline in the northern portion of the styrene plancor (benzene);
- Near the former butadiene plancor laboratory and associated pipelines (benzene); and
- Adjacent to a benzene feedstock pipeline at the southern end of the butadiene plancor (benzene).

Where feasible, indoor air monitoring was conducted at current buildings adjacent to the areas identified above. The indoor air data are discussed in Section 9.

6.1.3 Areas of Vadose Zone Contamination

While there are no appropriate direct-comparison regulatory criteria by which to determine the significance of soil gas VOC concentrations, the data remain highly useful for identification of areas of vadose zone contamination and potential groundwater contamination source areas. The data are also useful for modeling of contaminant transport and evaluating human health risks, which are undertaken in the BRA (Geosyntec & URS, 2006). The soil gas data are summarized on Figure 26 with the sampling locations color coded to show the distribution of total VOC concentration ranges at the former plant site. As shown, areas of elevated concentrations are most common within the former styrene plancor, particularly where VOC storage tanks were formerly located. Other substantial areas of VOC contamination are located in the southeast portion of the butadiene plancor, in proximity to a former laboratory building and a subsurface benzene feedstock pipeline.

While not a regulatory standard or scientifically derived criteria, individual VOC concentrations of 5 ppmv or higher were frequently found to be associated with groundwater contamination source areas at the former plant site. This value was therefore used as a guideline for triggering further evaluation of the potential presence of source areas, which are further discussed in Section 12. Shallow soil gas sampling locations with one or more VOC concentrations of 5 ppmv or higher are flagged in Table 11 and are indicated by the purple, orange, and red symbols on Figure 26. Sampling locations with VOC concentrations that are less than 5 ppmv do not necessarily indicate similar low VOC concentrations at greater depth, since areas of soil contamination may be highly irregular in shape and dissolved contaminant plumes with elevated contaminant concentrations typically extend downgradient from source areas.

Chemical releases unrelated to rubber plant operations are suspected where significantly elevated concentrations of chlorinated solvents were detected, since these compounds are not known to have been used at the plant. The distribution of total chlorinated VOC concentration ranges in shallow soil gas is presented on Figure 27. The most significant area of elevated concentrations is at the southwestern corner of the copolymer plancor. Historical aerial photographs show a series of excavations were present in this area during a portion of the period in which the rubber plant was in operation, but no other information regarding the nature and use of the excavations is known. Regulatory agency file material for two businesses located immediately west of the former plant site document the historical use and storage of chlorinated solvents along with their presence in soil and groundwater. The preceding analysis and conclusions represent the best of

the Respondents' knowledge to date. EPA has not yet finalized its analysis and conclusions, as EPA's investigation of chlorinated solvent use at the former plant site is still ongoing. EPA may issue future amendments or addenda to this RI report in the event that new information becomes available.

6.1.4 Pipeline and Trench Transmission System Data

Shallow soil gas data from the pipeline and trench transmission system investigation was collected for both "priority" and "non-priority" pipeline segments as described in Section 4.3.11 above. Priority segments are those that carried concentrated VOC solutions and/or were located adjacent to current buildings and therefore have a greater potential for releases that could result in an exposure risk. Sampling was completed at 25-foot intervals along 100% of the priority segments. Non-priority transmission system segments were those located within or immediately upgradient of the water table VOC plume, contained only dilute VOC solutions (process effluent or surface runoff rather than VOC feedstock), and did not approach within 25 feet of a current building footprint. A total of 100 randomly located shallow soil gas sampling points were completed along "non-priority" pipeline segments to statistically evaluate the potential for associated VOC contamination.

All of the shallow soil gas data from the pipeline and trench transmission system investigation are included within the previously presented summary tables and figures and discussed above. However, the approach of sampling only a representative fraction of a targeted facility and statistically analyzing the data is unique to the non-priority pipeline segments, and warrants investigation-specific presentation of the data (rather than the media-specific format followed elsewhere in this report). The non-priority transmission system shallow soil gas data are summarized on Figure 28, with sampling locations color-coded to reflect detected total VOC concentrations. Individual VOC concentrations were less than the 5 ppmv screening criteria in 96% (96 out of 100 samples) of the non-priority sampling locations.

By statistical analysis of the data, as detailed in the technical memorandum regarding the transmission system (D&M, 1995d), it can be said with 80% certainty that if sampling was completed along the entire length of non-priority pipeline segments, VOCs would be detected at 5 ppmv or more at 2 to 7% of the sampling locations. Stated more simply, only a random, representative portion of the substantial network of former pipeline routes along which dilute VOC solutions may have been transported has been sampled. However, the data are sufficient to state with relative certainty that the frequency of VOC concentrations at or exceeding 5 ppmv or more in shallow soil gas along the unsampled portion of the pipeline network is low.

As previously explained in Section 5.1, detection of one or more VOCs at concentrations of 5 ppmv or more triggered completion of additional step-out sampling and further review of all available data to evaluate whether identification of a groundwater contamination source was appropriate. Identification of groundwater contamination source areas is further discussed in Section 12.

6.2 DEEP SOIL GAS

Collection of deep soil gas data was completed in 1993 as part of the MW-20 NAPL Focused Investigation (D&M, 1993b) and was limited to 12 sampling locations near the former tank farm in the styrene plancor. Sample depths ranged from 47 to 59 feet bgs, immediately above the water table.

Deep soil gas data are summarized in Table 13. Sampling locations are shown on Figure 29, which illustrates the ranges and spatial distribution of detected concentrations. While ten different VOCs were detected in the sample population, benzene concentrations were consistently far higher than those for other VOCs, ranging from 1,760 to 30,800 ppmv, with a 100% detection frequency. Ethylbenzene and toluene were also detected in most samples, but with maximum concentrations of only 310 and 189 ppmv, respectively.

The high benzene concentrations present in the deep soil gas samples are not representative of the vadose zone as a whole, as evident by the relatively low to non-detect concentrations in shallow soil gas samples from the same area. Given the depth of the deep soil gas samples, the high concentrations are interpreted to be associated with volatilization from benzene-contaminated groundwater (see Section 10) and/or NAPL (Section 11), which are known to be present in the area. Benzene concentrations are inferred to be much lower in shallow soil gas samples due to the fine-grained, low permeability sediments in the upper Bellflower aquitard that inhibit vapor migration. The natural attenuation of concentrations with increasing distance from the water table source also plays a role in the observed disparity in concentrations between deep and shallow soil gas samples.

While the high VOC concentrations in deep soil gas samples do not necessarily indicate an exposure risk at the surface, the data do support the likely presence of groundwater contamination source areas in the vicinity of the former tank farm within the styrene plancor. Further discussion of groundwater contamination source areas is presented in Section 12.

DEL AMO REMEDIAL INVESTIGATION REPORT

SOIL AND NAPL OPERABLE UNIT

7.0 SOIL DATA

Discussion of results for the surface, shallow, and deep soil zones by analyte type is presented below. Soil data include results for VOCs, SVOCs/PAHs, pesticides and PCBs, metals, and cyanide compound classes. A comprehensive reporting of all soil data is included in Appendix B. All soil sampling locations for which there are laboratory data are shown on Figure 18, and additional figures and tables cited below present sampling locations for specific depth zones and analyte classes.

Soil investigations did not normally include 1,3-butadiene as a target analyte since this compound is a gas at standard conditions and would rapidly volatilize to the atmosphere upon release. Results for this compound are limited to eight non-RI samples in the northwest corner of the copolymer plant, all of which are non-detect. For these reasons, no further discussion of 1,3-butadiene is presented with respect to soil. Cyanide, while a target analyte, was similarly not detected in any soil samples for which it was tested and is therefore not judged to be of concern or further discussed. Details regarding the number of samples for which cyanide was analyzed are included in the appropriate soil summary tables cited below.

7.1 SURFACE SOIL

Surface soil samples are defined as those collected from between zero and one foot bgs. RI surface soil samples were primarily collected in 1993 as part of the surface soil investigation, which was focused on three large areas of exposed soil (see Figure 23). Surface soil samples were collected in these areas due to the increased potential for human contact with soil contaminants based on the undeveloped nature of the areas and exposed ground surface.

Additional property development has occurred covering most of the areas of exposed surface soil since the time of the RI surface soil sampling. The only significant area of exposed surface soil remaining is a fenced area in the southwestern portion of the former plant site, between the Waste Pit Area (now capped) and Normandie Avenue. For these reasons, the potential for contaminant exposures related to surface soil has been greatly reduced since the RI was initiated.

Surface soil sample data for VOCs, SVOCs/PAHs, metals, and pesticides/PCBs are summarized in Tables 14 and 15. Results for each of these compound classes are discussed below.

7.1.1 VOCs

Surface soil samples were generally not collected for VOC analysis since these compounds would normally have volatilized to the atmosphere during the more than 30 years that have

passed since rubber plant operations ceased. VOC data for surface samples is limited to RI location SBL0434 and non-RI location GPL0032, within the former styrene plancor (Figure 18). VOCs detections were limited to very low concentrations (0.15 mg/kg or less, and below screening criteria) at these two sampling locations.

7.1.2 SVOCs/PAHs

Surface soil sampling locations analyzed for SVOCs/PAHs are presented on Figure 30, with concentration data provided for locations with screening criteria exceedances. Exceedances of soil screening criteria are limited to benzo(a)pyrene at SBL0427, adjacent to the former laboratory within the copolymer plancor.

7.1.3 Pesticides/PCBs

Pesticide/PCB sampling locations in surface soil are presented on Figure 31, with concentration data provided for locations with screening criteria exceedances. Screening criteria exceedances are limited to dichlorodiphenyltrichloroethane (DDT) isomers at three composite sample locations in the southwestern corner of the former plant site. The DDT exceedances are interpreted as being associated with the Montrose property west of the former plant site. The evidence for this is as follows:

- DDT was manufactured at the Montrose property;
- The area of DDT exceedances in surface soil is downwind from the Montrose property under the prevailing northwest to southeast wind conditions. Prevailing wind directions are documented in the Del Amo Waste Pit Area Ambient Air Quality/Soil Gas Characterization Report (D&M, 1995a); and
- DDT is not known to have been used at the former plant site, and no correlation is apparent between the limited area of DDT exceedances and historical rubber plant facilities.

7.1.4 Metals

Figure 32 shows locations of surface soil samples analyzed for metals, with concentration data provided for locations with screening criteria exceedances. Metals found at concentrations in excess of screening criteria are limited to arsenic at three composite sample locations. While the sampled area in the southern portion of the butadiene plancor was undeveloped at the time of sampling (1993), buildings and landscaping now occupy most of the area, as indicated on the 2004 photograph in Figure 3. Therefore, exposed surface soil (the original basis for sample collection) is generally no longer present in this area. Furthermore, the single detection of elevated arsenic in this area may no longer be representative of soil conditions, depending upon how the area was graded and prepared for development. Details regarding the grading operations

at the property are unknown. Surface soil sample locations with elevated arsenic in the southwestern corner of the former plant site are interpreted to be associated with the Montrose Chemical property to the west of the former plant site based on the following lines of evidence:

- Soil data indicate a source of arsenic in the eastern portion of the Montrose property (see Figure 11 in Dames & Moore's "Technical Memorandum, Assessment of Arsenic in Groundwater." [D&M, 1995b]).
- The Montrose site is directly upwind from the southwestern corner of the former plant site under prevailing wind conditions (D&M, 1995a); and
- The two composite samples with elevated arsenic concentrations in the southwestern corner of the former plant site (SSL0001-0006 and SSL0011-0013) also contain elevated concentrations of total DDT (all isomers; 7.5 and 11.8 mg/kg, respectively)

7.2 SHALLOW SOIL

Shallow soil samples were collected from ground surface to a maximum depth of 15 feet. Surface soil data are therefore a subset of the shallow soil data, and for this reason, there is some repetition in discussion of the results. Shallow soil data were collected between 1993 and 2003 as part of the following investigations: (1) the southern copolymer plancor stained area, (2) the southwestern styrene plancor storage area, (3) utility tank, (4) NAPL screening, (5) 2003 addendum, and (6) the various MW-20 investigations. Contaminant data are available for VOCs, SVOCs/PAHs, metals, pesticides/PCBs, and cyanide. Summaries of the shallow soil sample analytical results are provided in Tables 16 and 17.

7.2.1 VOCs

Figure 33 presents shallow soil sampling locations where VOCs were analyzed for, and highlights locations where one or more VOCs were present at concentrations in excess of their respective screening criteria. VOC screening criteria exceedances occur at 24 sampling locations. Compounds for which there are exceedances are limited to benzene (11 locations), ethylbenzene (11), TCE (7), styrene (1), and 1,2,4-trimethylbenzene (1). Former plant site facilities or features where these exceedances occur are as follows:

- The pits and trenches area in the southwestern copolymer plancor (TCE; locations SBL0247-249, SBL0302, SBL0404, SBL0473, and SBL0474);
- An area of stained surface soil in the southern copolymer plancor observed on historical aerial photographs (ethylbenzene, styrene; location SBL0036);
- VOC storage tanks in the styrene plancor tank farm and utility tank area (benzene, ethylbenzene, styrene; locations SBL0068, SBL0069, SGL0050, SBL0125, PZL0021);

- A styrene finishing unit within the styrene plancor (1,2,4-trimethylbenzene; location GPL0016);
- The process area of a styrene finishing unit (benzene, ethylbenzene; locations SBL0253 and SBL0254);
- The oil skimmer basin at a waste water treatment area in the northern copolymer plancor (benzene, ethylbenzene; locations SBL0383 and SBL0384);
- An area of soil contamination near the butadiene plancor laboratory and underground pipelines that may have carried VOC solutions (benzene, ethylbenzene; location SBL0123); and
- A benzene feedstock pipeline at the southern end of the butadiene plancor (benzene; locations GP6, GP8, GP10, GP11, and GP25).

Benzene and ethylbenzene were detected in shallow soil in excess of screening criteria at a higher frequency relative to other VOCs, indicative of the history of use of these compounds at the rubber plant and the selective targeting of former facilities where these compounds were present.

TCE was detected in excess of screening criteria at seven locations. TCE detections are concentrated in the vicinity of the “pits and trenches” feature at the former plant site. There is no known historical use of TCE at the rubber plant and the pits and trenches area is located in close proximity to other possible source facilities that are unrelated to the former plant site (see Section 6.1.3 for further discussion). The preceding analysis and conclusions represent the best of the Respondents’ knowledge to date. EPA has not yet finalized its analysis and conclusions, as EPA’s investigation of chlorinated solvent use at the former plant site is still ongoing. EPA may issue future amendments or addenda to this RI report in the event that new information becomes available.

7.2.2 SVOCs/PAHs

SVOC/PAH data were collected as part of the surface soil, utility tank, and 2003 Addendum investigations. Figure 34 shows sampling locations where SVOCs/PAHs were analyzed for, highlighting those where one or more compound concentrations exceeded screening criteria. For the 13 sample locations with screening criteria exceedances, 11 were from depths of 4.5 feet bgs or less, with the remaining two (SBL0299 and SBL0265) being from 6 and 10 feet bgs, respectively. SVOCs/PAHs for which there were screening criteria exceedances included benzo(a)pyrene (11 locations), benzo(a)anthracene (3), benzo(k)fluoranthene (3), benzo(b)fluoranthene (2), dibenzo(a,h)anthracene (3), indeno(1,2,3-cd)pyrene (1) and n-nitrosodiphenylamine (1). A breakdown of the relative frequency at which various concentration

ranges and screening criteria exceedances occurred for each of these compounds is presented in Table 17.

The following rubber plant facilities/features correspond to sampling locations where SVOC/PAH concentrations were in excess of screening criteria:

- The copolymer plancor laboratory and/or adjacent machine shop/cafeteria (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene; locations SBL0337, SBL0340, SBL0427 and SBL0430);
- Oil feed storage tanks in the copolymer plancor (benzo(a)pyrene; SBL0415);
- A waste water final effluent pit in the southern copolymer plancor (benzo(a)pyrene; SBL0265);
- A stained area in the southern copolymer plancor (N-nitrosodiphenylamine; SBL0036);
- Sulfur tar and slop oil tanks at a styrene finishing/benzene purification unit in the styrene plancor (benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and dibenzo(a,h)anthracene; SBL0309);
- Process areas within two styrene production and propane cracking units in the styrene plancor (benzo(a)anthracene, benzo(a)pyrene, benzo(k)fluoranthene, dibenzo(a,h)anthracene; SBL0299, SBL0330);
- The styrene plancor instrument/electrical machine shop (benzo(a)pyrene; SBL0328);
- The styrene plancor laboratory (benzo(a)pyrene; SBL0322); and
- A wastewater treatment oil skimmer basin in the northern butadiene plancor (benzo(a)pyrene; SBL0390).

Other possible contributing sources of detected PAHs that may not be associated with the rubber plant include asphalt pavement and automobile exhaust.

7.2.3 Pesticides/PCBs

Pesticide/PCB analyses were completed for shallow soil samples collected from soil borings shown on Figure 35. These data were collected as part of the RI surface soil and 2003 Addendum investigations, as well as non-RI investigations. Screening criteria exceedances were limited to four sampling locations with elevated concentrations of DDT isomers and a single sampling location with elevated PCBs. Screening criteria exceedances occurred in the following investigation areas:

- The northwestern corner the former copolymer plancor (Aroclor 1260 at boring B-20);

- Within the stained area in the southwestern corner of the copolymer plancor (4,4'-DDT; location SBL0301); and
- Within the area of exposed surface soil in the southwestern corner of the styrene plancor (DDT isomers; composite surface soil sampling locations SSL0001-0006, SSL0007-0010, and SSL0011-0013).

Pesticides and PCBs generally do not migrate through soil as readily as VOCs, and elevated concentrations would generally be expected to be limited to the shallow subsurface. This is reflected in the shallow soil data (Table 16), which show that with one exception (Aroclor 1260 at boring B-20, 7 feet bgs), all the pesticide/PCB exceedances occurred in samples collected at or very near the surface (depths of 1.5 feet or less).

The pesticide and PCB exceedance locations do not correspond with known rubber plant facilities or operational areas. The DDT screening criteria exceedances in the southwestern corner of the former styrene plancor are identical to the surface soil samples previously identified and described in Section 7.1.3.

7.2.4 Metals

Sampling locations where metals were analyzed for are indicated on Figure 36. Metals data were generated primarily from the surface soil and the 2003 Addendum investigations. For sampling locations along the footprint of former cooling towers, metals analyses were limited to total chromium and hexavalent chromium. Data for the remaining locations typically include results for a suite of approximately 17 individual metals.

Metals for which there were detections in excess of the soil screening criteria include arsenic (9 locations), copper (3 locations), thallium (3 locations), and lead (1 location). Rubber plant facilities or features where screening criteria exceedances occurred are as follows:

- The area of formerly exposed surface soil in the northwestern copolymer plancor (arsenic, location B-23);
- The copolymer plancor laboratory (arsenic, lead; locations SBL0344, SBL0348, and SBL0425);
- An area adjacent to a former styrene finishing/benzene purification unit within the styrene plancor (thallium; SSL0085 and SSL0087);
- The area of exposed surface soil in the southern styrene plancor (arsenic; composite sampling locations SSL0001-SSL0006 and SSL0011-SSL0013);
- The unlined waste water treatment impoundment in the northern butadiene plancor (copper at locations SBL0274 and SBL0275; thallium at SBL0274);

- An incinerator in the northern butadiene plancor (arsenic; location SBL0380);
- A filtration tank in the northern butadiene plancor (arsenic; location SBL0388);
- The area of formerly exposed surface soil in the southern butadiene plancor (arsenic; location SBL0470 and composite sample location SSL0037-0042); and
- A copper solvent tank within the butadiene plancor (copper; location SBL0465).

The arsenic, thallium and lead exceedances were all in samples collected at or near the surface (4 feet bgs or less). The samples with elevated copper were collected from between 2 and 14 feet bgs. The 14-foot depth for one of the copper exceedances is for a sample from the vicinity of a former copper solvent tank (boring SBL0465), suggesting that the copper at this location was released in solution.

7.2.5 pH

Analyses for pH were limited to three samples collected from a former neutralization basin in the butadiene plancor (borings SBL0223, SBL0224 and SBL0233) and a single boring (SBL0263) at a former dry well location in the styrene plancor. Results are included in Table 16 and indicate the pH for the samples ranged from 8.1 to 10.0. Soil is considered hazardous waste when the pH is ≤ 2 or ≥ 12.5 .

7.3 DEEP SOIL

Deep soil samples are defined as those collected from depths of more than 15 feet bgs. Deep soil samples were collected between 1993 and 2003 as part of the southern copolymer plancor stained area investigation, various MW-20 area investigations, the southwestern styrene plancor storage area and utility tank investigations, the NAPL screening investigation, and the Waste Pit Area investigation⁸. Deep soil data is also available from non-RI investigations completed in the southeastern portion of the butadiene plancor, and in the central portion of the styrene plancor. Deep soil data are available for VOCs, SVOCs/PAHs, metals, pesticides/PCBs, and cyanide. A summary of detected analyte concentrations for all deep soil samples is provided in Table 18. A statistical summary showing the relative frequency of detections for various compounds is provided in Table 19.

While PRGs are used in this report for evaluation of the deep soil data, these criteria are likely very conservative in light of the limited potential for exposure to soil that is at a depth of 15 feet or more. This is well below the depths reached during standard utility line maintenance and construction project excavations. Nevertheless, the criteria serve as benchmarks for identification

⁸ Waste pit investigation data are not typically included or discussed in this report. The data referred to here were collected as part of the waste pit area investigation, but at a location just north of the waste pit area boundary and are therefore included in the Soil and NAPL RI database.

of areas where contaminant concentrations are elevated relative to other locations. The limited potential for exposure from deep soil contamination was taken into further consideration in the BRA, where the deep soil data of interest was limited to VOCs. VOCs are the only contaminants tested for which have a potential for surface exposure through upward vapor migration.

7.3.1 VOCs

Figure 37 illustrates deep soil sampling locations where VOCs were analyzed for, with locations where PRG exceedances were detected highlighted. VOC screening criteria exceedances occurred at 31 soil boring locations. VOCs for which screening criteria exceedances occurred were limited to benzene (31 locations) and ethylbenzene (two locations). Exceedances occurred in the following areas of the former plant site:

- Near former VOC storage tanks at the MW-20 area of the styrene plancor (benzene; borings OWL008A, SBL0088, SBL0089, SBL0090, SBL0091, SBL0093, and SBL0094);
- At the pumps and reactors for a styrene production facility within the styrene plancor (benzene; location SBL0259);
- Adjacent to aboveground “utility tanks” used for VOC storage in the southern styrene plancor (benzene, boring PZL0021);
- Adjacent to the Waste Pit Area (benzene; boring SBL0075);
- The butadiene plancor laboratory and/or adjacent pipelines (benzene and ethylbenzene; boring SBL0123);
- A benzene feedstock pipeline in the southern butadiene plancor (benzene; boring SBL0124 and numerous non-RI borings).

VOCs are generally more soluble and mobile than the other contaminants analyzed for as part of the RI. Therefore, they are the most likely to be present in deep soil. While the risk of direct exposure to VOCs is reduced for deep soil relative to shallow soil, elevated concentrations in deep soil are more likely to be indicative of a groundwater contamination source area due to closer proximity of the water table. Each of the areas with elevated deep soil VOC concentrations discussed above has been identified as a groundwater contamination source area, as discussed in Section 12 below.

7.3.2 SVOCs/PAHs

SVOC/PAH analyses of deep soil samples were limited to the 23 sampling locations indicated on Figure 38. There were no screening criteria exceedances at any of these locations. SVOC/PAH detections in deep soil were limited to phenol, dibutylphthalate, dimethylphthalate,

phenanthrene, and pyrene. As discussed in Section 7.2.2, exceedances in shallow soil (<15 feet bgs) were usually from within the upper 4.5 feet.

7.3.3 Pesticides/PCBs

Pesticides/PCB analyses in deep soil samples were limited to the 9 locations shown on Figure 39. Pesticides/PCBs were not present at detectable concentrations in any of the deep soil samples analyzed. Pesticides/PCBs are known to strongly adsorb to soil particles and have relatively low solubilities, limiting their mobility and potential migration to deeper soil.

7.3.4 Metals

Locations where metals were analyzed for in deep soil are limited to the southern copolymer plancor and southern styrene plancor (Figure 40). Screening criteria exceedances are limited to manganese at a sample from boring SBL0075, adjacent to the Waste Pit Area. The origin of the elevated manganese is unknown, and its presence is inconsistent with metals data for shallow soil, where manganese was not detected at elevated concentrations in any samples.

**8.0 SHALLOW SOIL AND SOIL GAS
SCREENING CRITERIA EXCEEDANCE AREAS**

The discussion below provides additional detail regarding results for former plant site areas where exceedances of shallow soil and soil gas screening criteria occur. Whereas Sections 6-10 summarize screening criteria exceedances for each analyte class (VOC, SVOC, metals, etc) throughout the former plant site, results in this section are organized by geographic area (identified by the former plancor and plancor facilities present), with exceedances for all analyte classes presented together. The discussion is focused on areas where clusters of screening criteria exceedances occur since these are the areas most likely to have health risks and be considered for remediation in the FS. Areas with only isolated screening criteria exceedances occur are briefly identified and summarized in tables.

Analytical results discussed below and presented in the referenced figures are limited to screening criteria exceedances. A comprehensive summary of the analytical program and results for each location are presented in Tables 11 and 16 (shallow soil gas and shallow soil data summaries, respectively).

8.1 COPOLYMER PLANCOR

8.1.1 Laboratory and Machine Shop

The laboratory and machine shop facilities were located in the northeastern corner of the copolymer plancor. This area was characterized as part of the soil gas and 2003 Addendum investigations.

Screening criteria exceedances in the laboratory and machine shop area were limited to seven soil sample locations, as indicated on Figure 41. Screening criteria exceedances occurred for the following analytes:

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Shallow Soil	SVOCs/ PAHs	Benzo(a)pyrene	4	13	0.21 (Ind. PRG)
		Benzo(a)anthracene	1	4.8	2.1 (Ind. PRG)
		Benzo(b)fluoranthene	1	10	2.1 (Ind. PRG)
		Benzo(k)fluoranthene	1	6.7	1.3 (Ind. PRG)
		Dibenzo(a,h)anthracene	1	1.7	0.21 (Ind. PRG)
		Indeno(1,2,3-c,d)pyrene	1	19	2.1 (Ind. PRG)
	Metals	Arsenic	2	14	10 (Background)
		Lead	1	586	150 (Res. PRG)

PAH exceedances were limited to a cluster of four neighboring soil borings near the southwestern corner of the former laboratory, including SBL0337, SBL0340, SBL0427, and SBL0430. The PAH-impacted soil is inferred to be limited to a depth of less than six feet and laterally to the immediate vicinity of the exceedance locations based on the analytical data and field observations of hydrocarbon staining and odors (see boring logs in Appendix C). Documentation regarding specific activities at the former laboratory is not available and therefore it is unclear if the elevated PAH concentrations may be associated with releases from the former laboratory.

The metal exceedances are near the southeastern and southwestern corners of the former machine shop/cafeteria building (borings SBL0344, SBL0348 and SBL0425; see Figure 41). Arsenic is not known to have been used at the former plant site, but is intermittently present in surface and near-surface soil samples (<2 feet bgs) at concentrations above the screening criteria of 10 mg/kg. Elevated concentrations of lead at the former plant site are limited to boring SBL0348. While metals data for the machine shop area is limited, it is inferred from the isolated occurrences of the exceedances and the generally low mobility of these analytes that the metal-impacted soil is limited to the general vicinity of borings SBL0344, SBL0348 and SBL0425. There is no documentation linking the elevated metals concentrations with former plant site facilities. However, the elevated lead concentrations in the vicinity of a former machine shop suggests a potential association. The arsenic exceedances (10.8 and 14 mg/kg) are only slightly above estimated background conditions (10 mg/kg), and are less likely to be associated with the machine shop.

8.1.2 Pits and Trenches

The pits and trenches feature was located in the southwestern corner of the copolymer plancor. It is inferred to have consisted of a series of shallow excavations based on review of historical aerial photographs of the former plant site; no other documentation confirming their existence or

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

indicating their use is known. This area was characterized as part of the soil gas and 2003 Addendum investigations.

Shallow soil gas and soil sampling locations and exceedances are indicated on Figure 42. Soil gas exceedances are limited to TCE and PCE, which were detected above the 5 ppmv field screening criteria at six locations. Maximum concentrations were 540 and 210 ppmv, respectively, both of which occur at SGL0357.

Shallow soil exceedances occur at nine locations and for the following analytes:

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Shallow soil	VOCs	TCE	7	0.29	0.053 (Res. PRG)
		Ethylbenzene	1	4,300	8.9 (Res. PRG)
		Styrene	1	15,000	1,700 (Res. PRG)
	SVOCs	N-nitrosodiphenylamine	1	280	99 (Res. PRG)
	Pesticides	4,4'-DDT	1	7.4	1.7 (Res. PRG)

Shallow soil exceedances were limited to TCE, with the exception of SBL0301, where an exceedance for 4,4'-DDT occurred, and SBL0036, where elevated ethylbenzene, styrene, and n-nitrosodiphenylamine (NDPA) concentrations occurred. SBL0301 and SBL0036 are both located north of the pits and trenches footprint.

The Respondents believe that the elevated concentrations of TCE are not associated with the pits and trenches feature or the rubber plant for the following reasons:

- (1) There is no documentation indicating the use of TCE or similar chlorinated solvents at the rubber plant;
- (2) The maximum detected TCE concentration occurs outside of the pits and trenches footprint; and
- (3) There are known, TCE source areas immediately west and southwest of the pits and trenches feature that are unrelated to the former plant site. Data supporting the presence of these source areas was provided to EPA via email in a November 20, 2003 memorandum (URS, 2003b).

The lateral extent of the TCE/PCE-impacted shallow soil was not fully delineated as part of the RI due to the presence of the source areas to the west of the former plant site (under separate

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

investigation) and an occupied building to the east and south of the pits and trenches area that limited access. The area has been identified as a groundwater contamination source area since TCE and PCE-impacted shallow soil is present and water table groundwater data indicate these compounds are present at concentrations in excess of drinking water MCLs. EPA's investigation of chlorinated solvents at the former plant site and vicinity is ongoing.

The ethylbenzene, styrene, and NDPA exceedances in soil are isolated occurrences, limited to boring SBL0036, located just north of the pits and trenches footprint (Figure 42). The ethylbenzene, styrene, and NDPA exceedances at boring SBL0036 are associated with a thin, hydrocarbon stained layer that was also observed in other soil borings further to the north and northeast. The distribution of this layer is consistent with a stained area identified at the former plant site (see Figure 23) that was investigated independently (see Section 4.3.5) and is not associated with the pits and trenches feature.

The single shallow DDT exceedance occurred at boring SBL0301 (1.5 feet bgs). The origin of the DDT is not known, but its isolated occurrence outside of the pits and trenches footprint suggests it is also unrelated to the feature.

8.1.3 Other Areas

Outside of the laboratory/machine shop and pits and trenches areas discussed above, screening criteria exceedances in the copolymer plancor are limited to isolated occurrences (single locations). These impacted areas do not extend significantly beyond the immediate vicinity of the sampling location where the exceedance was detected, based on laboratory data for surrounding sampling locations. Pertinent information regarding these "other area" exceedances is presented in the table below along with a reference to a previously presented figure where the exceedance locations are shown. The former plant site facility/feature at or adjacent to the sampling location with each exceedance is noted in the table, although there is no additional evidence linking the contaminants with the former facilities. The isolated nature of these exceedances make them less likely to be associated with extensive areas of contamination and health risks, and they are therefore less significant than areas with multiple exceedances.

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Medium	Former Facility	Sampling Location	Sample Depth (ft)	Analyte With Exceedances	Detected Concentration and Units	Screening Criteria Exceeded	Location Reference (Figure # / Coordinates)
Shallow soil	Waste transfer stn.	B-20	7	Aroclor 1260	0.42 mg/kg	0.22 mg/kg (Res. PRG)	18 / B3
	Butadiene tanks	SBL0415	1.5	Benzo(a)pyrene	0.25 mg/kg	0.21mg/kg (Ind. PRG)	18 / C3
	Final effluent pit	SBL0265	10	Benzo(a)pyrene	0.22 mg/kg	0.21 mg/kg (Ind. PRG)	18 / D4
Shallow soil gas	Secondary effluent separator	SGL0335	6.5	Ethylbenzene	5.5 ppmv	5 ppmv (Field screen)	24 / B4
	Underground pipelines	SGL0762	7	Freon 113	8 ppmv	5 ppmv (Field screen)	24 / D6

8.2 STYRENE PLANCOR

8.2.1 MW-20 and Tank Farm

The MW-20 and tank farm area is located in the western portion of the styrene plancor. This area was characterized primarily through the various MW-20 NAPL and soil gas investigations.

Shallow soil gas sampling locations and historical features for the area are presented on Figure 43. Soil gas screening criteria exceedances were detected for the following analytes:

Medium	Class	Analyte	No. of	No. of	Maximum Concentration (ppmv)	Threshold Criteria (ppmv)
			Threshold Exceedances	field screening (5 ppmv) exceedances		
Shallow Soil Gas	VOCs	Ethylbenzene	2	34	18,000	3,000
		Benzene	11	16	1,700	30
		PCE	0	7	25	3,000
		Toluene	0	6	410	3,000
		Styrene	1	5	1,900	1,500
		1,2-dichlorobenzene	0	1	45	None
		1,4-dichlorobenzene	0	1	37	None

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Benzene, ethylbenzene, styrene and toluene account for the majority of the soil gas screening criteria exceedances and occur in the vicinity of former tank locations where the chemicals are known to have been stored. PCE is not known to have been used at the former plant site. The PCE exceedances occur in proximity to former railroad tracks as well as a current building. The dichlorobenzene exceedances are limited to a single location (SGL0005), where benzene, ethylbenzene, styrene and toluene exceedances also occurred.

Shallow soil sampling locations and historical features for the area are presented on Figure 44. Soil screening criteria exceedances were detected for the following analytes:

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Soil	VOCs	Ethylbenzene	5	12,000	8.9 (res. PRG)
		Benzene	1	300	0.6 (res. PRG)

The above exceedances all occur in the vicinity of former VOC storage tank locations.

The lateral extent of VOC-impacts in the shallow subsurface is considered to be reasonably well delineated by the distribution of soil gas exceedances (solid black triangles in Figure 43). VOCs are known to have migrated vertically and impacted the water table in this area, as evidenced by elevated dissolved concentrations and the presence of NAPL. The areas of soil and soil gas exceedances identified at the MW-20 /tank farm area are considered to be within groundwater contamination source areas #3 and #6, as discussed in Section 12.

8.2.2 Styrene Finishing/Benzene Purification and Styrene Production/Propane Cracking Units

The styrene finishing/benzene purification and styrene production/propane cracking units are located in the central portion of the styrene plant. Styrene was produced from ethylbenzene feedstock and purified in these areas. Various aromatic VOCs including benzene, toluene, isopentane and styrene, as well as smaller volumes of “sulfur tar oil” and “slop oil” were stored in the area. This area was characterized as part of both the soil gas investigation and the 2003 Addendum Investigation. Soil sampling in the area was also completed as part of non-RI investigations.

Shallow soil and soil gas sampling locations and historical facilities for the area are presented on Figure 45. Shallow soil gas screening criteria exceedances occur for one or more of the following analytes at nine sampling locations:

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Medium	Class	Analyte	No. of Threshold Exceedances	No. of Field Screening (5 ppmv) Exceedances	Maximum Concentration (ppmv)	Threshold Criteria (ppmv)
Shallow Soil Gas	VOCs	Cyclohexane	0	5	420	9,000
		Ethylbenzene	0	5	76	3,000
		Benzene	0	4	16	30
		Toluene	0	4	22	3,000
		Styrene	0	2	23	1,500
		Xylenes (total)	0	1	5.9	3,000
		PCE	0	1	22	3,000
		1,2-dibromomethane	1	0	4.9	3.9

The cyclohexane exceedances primarily occur near the former styrene finishing/benzene purification unit process area (top of Figure 45). While cyclohexane storage tank locations are unknown, this VOC is known to have been used at the rubber plant. The benzene, toluene, ethylbenzene, styrene and xylenes exceedances occur primarily within the styrene production/propane cracking process area (bottom of Figure 45).

The PCE exceedance is along the eastern edge of a current building. A PCE degreaser was present in the building at the time of the sampling and is unrelated to former plant site facilities. The origin of the 1,2-dibromomethane (aka ethylene dibromide, or EDB) is unknown. EDB was not detected in any of the 303 other soil gas sampling locations where it was tested for.

Shallow soil screening criteria exceedances were detected at a total of five sampling locations for one or more of the following analytes:

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Shallow soil	VOCs	1,2,4-trimethylbenzene	1	76	52 (Res. PRG)
	PAHs	Benzo(a)anthracene	1	2.5	2.1 (Ind. PRG)
		Benzo(a)pyrene	1	2.2	0.21 (Ind. PRG)
		Benzo(b)fluoranthene	1	2.7	2.1 (Ind. PRG)
		Benzo(k)fluoranthene	1	2.1	1.3 (Ind. PRG)
		Dibenzo(a,h)anthracene	2	0.66	0.21 (Ind. PRG)
	Metals	Thallium	2	12	5.2 (Res. PRG)

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

The above exceedances occur primarily in the vicinity of former plant site VOC and oil storage tank locations. While the VOCs and PAH exceedances are all consistent with former plant site facilities, the origin of the elevated thallium is unknown. Other former plant site locations with elevated thallium are limited to a single sampling location near a wastewater impoundment near the northeastern corner of the copolymer plancor.

While areas with screening criteria exceedances appear to be limited based on the laboratory analytical data, review of the soil boring logs indicates a more extensive area of soil staining and/or hydrocarbon and sulfur odors that is approximately delineated on Figure 45. VOC releases from this area are also inferred to have migrated to groundwater and the area is identified as groundwater contamination source area #4 (see Section 12).

8.2.3 Styrene Finishing Area

The styrene finishing area was located in the central portion of the styrene plancor. Styrene was produced from ethylbenzene feedstock and purified in this area, which was characterized as part of both the soil gas investigation and the 2003 Addendum Investigation.

Shallow soil and soil gas sampling locations and historical facilities for the area are presented on Figure 46. Shallow soil gas screening criteria exceedances occur at three sampling locations for one or more of the following analytes:

Medium	Class	Analyte	No. of Threshold Exceedances	No. of Field Screening (5 ppmv) Exceedances	Maximum Concentration (ppmv)	Threshold Criteria (ppmv)
Shallow Soil Gas	VOCs	Benzene	1	3	210	30
		Ethylbenzene	0	3	620	3,000
		Toluene	0	3	59	3,000
		Styrene	0	1	27	1,500
		Xylenes (total)	0	1	43	3,000

The above VOC exceedances occur in proximity to the former locations of a skimmer basin and VOC storage tanks (SGL0704, SGL0707, SGL0327) and are consistent with the chemicals handled at these facilities.

Shallow soil screening criteria exceedances were limited to two sampling locations for the following analytes:

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Shallow Soil	VOCs	Benzene	2	6.4	0.6 (Res. PRG)
		Ethylbenzene	2	170	8.9 (Res. PRG)

The above exceedances occur within the styrene finishing process area (SBL0253 and SBL0254) and are consistent with the chemicals handled there.

The lateral extent of the VOC-impacts in the shallow subsurface in the styrene finishing area is not fully known due to access limitations imposed by existing buildings. VOCs in proximity to the styrene finishing are inferred to have impacted the water table based on groundwater quality data, and the area is identified as groundwater contamination source area #5 in Section 12 of this report.

8.2.4 Southwest Surface Soil Area

The southwest surface soil area is located in the southwestern corner of the former styrene plant. Rubber plant facilities in this area were limited to railroad tracks and an equipment storage area. The area was characterized as part of the surface soil and southwestern styrene plant storage area investigations.

Screening criteria exceedances for the southwest surface soil area are limited to shallow soil samples. Shallow soil sampling locations and historical facilities for the area are presented on Figure 47. Screening criteria exceedances are limited to the following analytes:

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Shallow	Pesticides	4,4'-DDT	3	9.1	1.7 (Res. PRG)
		4,4'-DDE	1	2.2	1.7 (Res. PRG)
		4,4'-DDD	1	2.7	2.4 (Res. PRG)
	Metals	Arsenic	2	30	10 (Background)

The southwestern surface soil area, along with the LADWP utility corridor at the southern end of the former plant site, are unique in that they have not undergone the extensive grading, redevelopment, and landscaping that has occurred over the remainder of the former plant site since decommissioning of the rubber plant. Therefore, the DDT- and arsenic-impacted surface soil that is present in this area is unlikely to extend laterally beyond the vicinity of the composite

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

sample locations shown in Figure 47. Furthermore, arsenic and DDT concentrations are not elevated at 7 and 5 feet bgs at soil borings SBL0065 and SBL0066, indicating that the impacts are limited to very shallow depths. The elevated arsenic and DDT are inferred to be unrelated to the rubber plant and to have originated from a source northwest of the former plant site, as discussed in Sections 7.1.3 and 7.1.4.

8.2.5 Other Areas

Styrene plancor areas with few, relatively isolated exceedances are summarized in the table below. The former plant site facility/feature at or adjacent to the sampling location with the exceedance is noted, but there is no further evidence linking the contamination with the facility. Due to the limited extent of impacts, these isolated exceedances are not as significant as areas with multiple exceedances.

Medium	Former Facility	Sampling Location	Sample Depth (ft)	Analytes With Exceedances	Detected Concentration and Units	Screening Criteria Exceeded	Location Reference (Figure # / Coordinates)
Shallow Soil	Instrument/electrical machine shop	SBL0328	2	Benzo(a)pyrene	0.74 mg/kg	0.21 mg/kg (Res. PRG)	18 / F6
	Process area in styrene production/ propane cracking unit #2	SBL0330	2.5	Benzo(a)anthracene	3.9 mg/kg	2.1 mg/kg (Ind. PRG)	18 / F5
				Benzo(a)pyrene	2.6 mg/kg	0.21 mg/kg (Ind. PRG)	18 / F5
				Benzo(k)fluoranthene	1.4 mg/kg	1.3 mg/kg (Ind. PRG)	18 / F5
	Laboratory	SBL0322	1.5	Benzo(a)pyrene	0.26 mg/kg	0.21 mg/kg (Ind. PRG)	18 / G6
Utility Tanks	PZL0021	9	Ethylbenzene	82 mg/kg	8.9 mg/kg (Res. PRG)	18 / H3	
Shallow Soil Gas	VOC tanks at ethylbenzene production unit #2	SGL0249	6.5	Ethylbenzene	64 ppmv	5 ppmv (field screen)	24 / G5

8.3 BUTADIENE PLANCOR

8.3.1 Water Treatment Area

The water treatment area serviced wastewater from each of the three plancors and was located in the northeastern corner of the butadiene plancor. Treatment facilities included various filtration tanks, skimmer basins, holding tanks, and impoundments. The area was characterized as part of both the soil gas investigation and 2003 Addendum Investigation.

Shallow soil gas and soil sampling locations along with historical facilities for the area are presented on Figure 48. Screening criteria exceedances are limited to one or more of the following analytes at seven soil sampling locations:

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Medium	Class	Analyte	No. of Exceedances	Maximum Concentration (mg/kg)	Screening Criteria (mg/kg)
Shallow soil	VOCs	Benzene	2	2.7	0.6 (Res. PRG)
		Ethylbenzene	2	55	8.9 (Res. PRG)
	PAHs	Benzo(a)pyrene	1	0.22	0.21 (Ind. PRG)
	Metals	Arsenic	2	19.2	10 (Background)
		Copper	2	40,700	3,100 (Res. PRG)
		Thallium	1	6.3	5.2 (Res. PRG)

The elevated VOC concentrations at SBL0383 and SBL0384 occur within the footprint of a former oil skimmer basin, where VOCs might be expected. The sole PAH exceedance occurs at a step-out sampling location (SBL0390) where no former facility is known to have been present. The copper and thallium exceedances occur where a former unlined impoundment was present, and the arsenic exceedance lies within the footprint of a former incinerator. Copper solutions are commonly used as algicides, and thus might be expected within a water treatment impoundment. The origins of the arsenic and thallium are unknown.

The lateral extent of the impacted shallow soil is inferred to be limited to the immediate vicinity of the sampling locations where the exceedances occur based on the distribution of the exceedances relative to the total population of sampling locations. Groundwater in this area has not been significantly impacted by VOCs, and PAHs are similarly believed to be confined to the shallow subsurface based on their limited mobility and lack of detection at greater depths (non-detect for SBL0390 at 7 feet bgs). While metals data from below the samples with exceedances is lacking, metal mobility is typically relatively low and elevated concentrations are unlikely to extend to deep soil and the water table. The water treatment area has not been identified as a groundwater contamination source area.

8.3.2 Laboratory/Pipelines

The laboratory/pipelines area is located near the southeastern corner of the butadiene plancor. There is no documentation regarding historical laboratory activities and practices.

This laboratory/pipelines area was investigated as part of the soil gas, pipeline, NAPL screening, and 2003 Addendum investigations. Shallow soil gas sampling locations along with historical facilities for the area are presented on Figure 49. Shallow soil gas screening criteria exceedances were detected at 39 locations for one or more of the following analytes:

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

Medium	Class	Analyte	No. of Threshold Exceedances	No. of Field Screening (5 ppmv) Exceedances	Maximum Concentration (ppmv)	Threshold Criteria (ppmv)
Shallow soil gas	VOCs	Benzene	31	35	2,000	30
		Cyclohexane	0	26	3,300	9,000
		Toluene	0	19	160	3,000
		Xylenes (total)	0	14	310	3,000
		Ethylbenzene	0	8	190	3,000
		1,2,4-Trimethylbenzene	Not Applicable	1	17	None
		4-Ethyltoluene	Not Applicable	1	13	None
		Heptane	Not Applicable	2	1,100	None
		n-Hexane	Not Applicable	2	17	None

The above exceedances are primarily grouped in four sub-areas that are each in proximity to known underground pipelines and/or the former technical center/laboratory, as shown on Figure 49. A color-coded map indicating which sampling locations are in various total-VOC concentration ranges is presented on Figure 26.

Shallow soil sampling in the subject area was focused on PAH analyses, with limited VOC data due to the large volume of VOC soil gas data available. Shallow soil sampling locations and screening criteria exceedances are presented on Figure 50. Detected exceedances were limited to benzene and ethylbenzene at a single location (SBL0123 at 15 feet bgs).

The approximate lateral extent of VOC-impacted soil is best illustrated by the distribution of shallow soil gas sampling locations with elevated total VOC concentrations on Figure 49. Water quality data (see Section 10) and the observed presence of NAPL indicate that VOCs have vertically migrated to the water table in this area. The area is identified as groundwater contamination source area #12, as discussed in Section 12.

While many of the VOCs with PRG exceedances listed above are known to be associated with the rubber plant, the nature and source of the releases resulting in the contamination is unknown. Operations at the former laboratory and/or solutions introduced into pipelines from the former laboratory are suspected as potential sources based on their known proximity to the areas of contamination, but there is no documentation available that otherwise supports this.

8.0 SHALLOW SOIL AND SOIL GAS SCREENING CRITERIA EXCEEDANCE AREAS

8.3.3 Benzene Feedstock Pipeline

The benzene feedstock pipeline was an underground, east-west trending pipeline in the southern portion of the butadiene plancor that supplied the benzene necessary for production of ethylbenzene and styrene. The pipeline extended into the southeastern corner of the styrene plancor, and thereafter it was aboveground.

The underground pipeline area was characterized as part of the soil gas and NAPL screening investigations, as well as numerous non-RI investigations completed by other investigators. Soil gas sampling locations and exceedances are presented on Figure 51. As shown, screening criteria exceedances are limited to benzene and primarily occur between two existing buildings. The maximum detected benzene concentration was 4,100 ppmv (SG-04 at 13 feet bgs). Shallow soil sampling locations and exceedances are presented on Figure 52. Soil exceedances are also limited to benzene, with a maximum concentration of 4 mg/kg.

The benzene screening criteria exceedances are inferred to be associated with leakage from the nearby pipeline that is documented to have been used for benzene transport during rubber plant operations. The lateral extent of benzene-impacted shallow soil is approximated by the distribution of shallow soil gas and soil sampling where exceedances occur. Deep soil and water table groundwater quality data (Sections 7.3 and 10) indicate that the benzene in this area has vertically migrated to the groundwater table. This area is identified as groundwater contamination source area #11, as discussed in Section 12.

8.3.4 Other Areas

Butadiene plancor areas with few, relatively isolated exceedances are summarized in the table below. The former plancor facility/feature in proximity to each exceedance location may or may not be associated with the respective exceedance analytes.

Medium	Former Facility	Sampling Location	Sample Depth (ft)	Analytes With Exceedances	Detected Concentration and Units	Screening Criteria Exceeded	Location Reference (Figure # / Coordinates)
Shallow Soil gas	Slop oil tank	SGL0448	6	Benzene	5.8 ppmv	5 (Field screen)	24 / H8
Shallow Soil	Exposed surface soil area	SSL0037-42 (composite)	0.5	Arsenic	14 mg/kg	10 (Background)	18 / G8
	Copper Solvent Tank	SBL0465	14	Copper	5750 mg/kg	3,100 (Res. PRG)	18 / G7
		SBL0470	1.5	Arsenic	17.5 mg/kg	10 (Background)	18 / G7

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9.0 INDOOR AIR DATA

Indoor air data were collected as part of the WAM investigation completed between 1993 and 1995, and were previously presented in a 2001 report (URS, 2001c). The investigation included the 13 buildings indicated on Figure 53. Indoor air sampling was completed at these buildings to evaluate whether there was an immediate health risk to building occupants. Buildings were selected for indoor air sampling because (1) their footprint covers a former plant site VOC-facility location that would otherwise have required disruptive soil gas or soil sampling for evaluation; and/or (2) they are located immediately adjacent to soil contamination, as known from soil gas data indicating contaminant concentrations in excess of threshold values (Figure 25).

Several buildings originally proposed for indoor air sampling were excluded due to various circumstances. Access for the building at the southeast corner of the butadiene plancor was refused by the owner. Monitoring at the buildings located at 991 Knox Street (southern copolymer plancor) and 1000 Francisco Street (styrene plancor) was canceled due to business practices and/or building configurations that precluded meaningful interpretation of the data. For example, large roll-up doors that remain open for business purposes were present at the buildings that were excluded from the program. Additionally, the office portions of the buildings where there was consistent occupancy were also largely removed from the areas where the former plant site facilities of concern were located. USEPA's concurrence with deleting these buildings from the program is documented in a letter to Shell (USEPA, 1994). The building immediately north of parcel 7351-033-017 (see Figure 53, near southeast corner of the former plant site) is near soil gas sampling locations with threshold concentration exceedances (see Figure 25) but was not proposed for air monitoring because it was not present at the time of the WAM investigation (1993-95).

A comprehensive presentation of indoor air data is included in the WAM report (URS, 2001c) and the data are summarized here in Table 20. Evaluation of the data is complex due to inherent uncertainties with respect to the source of any contaminant detected. Possible sources of indoor VOC air contaminants include contaminated soil underlying the building, vehicles or equipment operated from within or near the building, building materials or supplies within or near the building, and various sources that are not related to either the rubber plant or the current land use. In short, there is not necessarily any association between detected contaminants in indoor air samples and the former plant site facilities or soil contamination that were the original impetus for the investigation. While having these drawbacks, the indoor air data have the advantage of presenting a clear snapshot of conditions within the building that workers are exposed to, regardless of source. The risk to building occupants can be directly calculated when indoor air

9.0 INDOOR AIR DATA

data are available. Alternatively, the risks can be estimated through modeling of vapor migration using available soil or soil gas data, various assumptions regarding contaminant migration, and estimated attenuation factors.

The frequency of contaminant detection and ranges of concentrations detected for each building and VOC are provided in Table 20. VOCs were not detected in indoor air at any of the buildings at concentrations in excess of the PEL or PEL/20 criteria, indicating that no immediate health risk existed at the time the indoor air monitoring events were completed⁹. Additional evaluation of the indoor air data with respect to health risks is provided in the BRA (Geosyntec & URS, 2006).

While the above conclusion adequately addresses the original intent of the indoor air monitoring program to evaluate the potential for immediate health risks, further insight can be achieved through comparison of the data to ambient air PRGs. These PRGs are typically much more conservative than the PEL and PEL/20 criteria, as mentioned in Section 5.3. One or more VOCs were detected in excess of ambient PRG values in each of the buildings included in the monitoring program. The table below presents the frequency at which VOC detections exceeded PRGs as well as an indication of the magnitude of the PRG exceedances (average concentration / PRG) for the buildings where air monitoring was completed.

VOC	Indoor Air		Outdoor Air	
	Frequency of Detects in Excess of PRG (%)	Magnitude of PRG Exceedance (Average Concentration/PRG)	Frequency of Detects in Excess of PRG (%)	Magnitude of PRG Exceedance (Average Concentration/PRG)
Benzene	96	51	89	24.6
Ethylbenzene	94	6.5	89	3
PCE	73	13.9	60	5.2
Methylene chloride	36	1.1	18	0.4
TCE	26	167	10	73.3
Xylenes	10	0.5	0	0.2
Chloroform	2	2.4	3	2.3
Other VOCs	0	-	0	-

⁹ At the time of preparation of this RI Report, no changes in PEL values have been noted since the original evaluation of the indoor air data in the Workplace Air Monitoring Report (URS, 2001c)

Data for the building on parcel 7351-034-057 were excluded from the above summary because analyses there were limited to BTEX and styrene, with the detection limits for benzene exceeding its PRG value. This building was the first at which indoor air monitoring was completed. Sampling and analytical procedures were revised for all other buildings where indoor air monitoring was completed to expand the number of compounds analyzed for and reduce detection limits.

As indicated in the table above, with the exception of xylenes, the same VOCs were detected at concentrations in excess of PRGs in indoor air as in outdoor air. This strong similarity suggests a link between indoor and outdoor air conditions. However, PRG exceedances are slightly more frequent and of greater magnitude in indoor air than outdoor air. This suggests the presence of one or more contributing VOC sources near, under, or inside the buildings. These sources could be associated with the equipment and materials from the current businesses, and/or underlying soil contamination originating from the rubber plant. The relative contribution from rubber plant-associated contamination versus business-associated sources cannot be evaluated from the existing data. Observations made at the time of air monitoring indicate multiple potential VOC sources inside the buildings that are associated with the existing business, as detailed in the WAM report (URS, 2001c). Evaluation of the incremental health risk due to the unspecified VOC sources at the buildings are further evaluated in the BRA.

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10.0 GROUNDWATER TABLE VOC DATA

While soil and NAPL are the primary subjects of this RI, a limited discussion of groundwater conditions at the water table is appropriate since these data assisted in evaluating the potential for surface exposure from upward migration of vapor and in identification of groundwater contamination source areas and NAPL areas. A comprehensive presentation of groundwater conditions through 1995 is available in the Groundwater RI Report (D&M, 1998a) and in USEPA's groundwater ROD (USEPA, 1999a). Groundwater data from the 2000 monitoring event are used in this RI report, and in the BRA.

Groundwater data presented here are limited to VOCs since: (1) other contaminant classes have low vapor pressures and no significant potential for vapor migration and associated health risks; and (2) all known groundwater contamination source areas are primarily associated with VOCs. For the purposes of this RI, only the portion of the VOC plumes that lie within the boundaries of the former plant site are of concern, as this is the area for which risks were evaluated in the BRA.

Unlike soil and soil gas data, there are typically multiple concentration values for a given groundwater contaminant and monitoring well location because multiple sampling events have occurred during the course of the RI. Data summary figures and tables presented here are for the 2000 groundwater monitoring event, the most recent data available at the time that this RI report and the BRA were prepared. For those locations where 2000 data are not available, the most recent previous data are presented. Time-series groundwater data are available in the 2000 Groundwater Monitoring Report (URS, 2001a).

Comprehensive water table VOC results for the 2000 groundwater monitoring event are included in Appendix B. VOC detections are summarized on Figure 54 and the frequency of MCL exceedances for each VOC detected in groundwater is presented in Table 21.

Benzene is by far the VOC most frequently detected at concentrations in excess of its Cal MCL, and is generally found at higher concentrations and over a larger area than other VOCs. This is consistent with the known use of this compound at the rubber plant and the soil and soil gas data, which similarly show benzene to be the compound most frequently detected at elevated concentrations. As such, the distribution of dissolved benzene is used as an indicator for groundwater contamination associated with the former plant site.

The extent of the dissolved benzene plume within the water table zone is presented in Figure 55. As shown, there is an eastern plume area in the southern portion of the former butadiene plancor and a western plume area in the central and southern portion of the styrene plancor. The benzene

10.0 GROUNDWATER TABLE VOC DATA

distribution further suggests that the two main plume areas have formed through the coalescing of smaller plumes originating from individual source areas. Sources unrelated to the former plant site are interpreted to have contributed to portions of the benzene plume that extend downgradient beyond the boundaries of the former plant site. Groundwater contamination source areas within the former plant site are discussed in Section 12.

Ethylbenzene is also commonly detected in water table wells at the former plant site. Ethylbenzene has a distribution pattern similar to that for benzene, although concentrations are typically lower than for benzene at a given location (Figure 56). The distribution of other VOCs and further discussion of water table zone VOC conditions is presented within the Groundwater RI Report (D&M, 1998a).

Groundwater investigations typically did not include 1,3-butadiene as a target analyte since this compound is a gas at standard conditions and would rapidly volatilize to the atmosphere upon release. A limited program for evaluating 1,3-butadiene in groundwater using specially developed laboratory techniques to reduce the detection limit was completed in 2000; however, this data was subsequently rejected for use in the RI database at USEPA's request based on their concerns regarding the laboratory methods. No further groundwater sampling or testing for 1,3-butadiene has been completed.

11.0 NAPL

11.1 NAPL DEFINITIONS AND BEHAVIOR

Non-Aqueous Phase Liquid (NAPL) refers to contamination that is present in a concentrated liquid phase rather than dissolved in groundwater or adsorbed onto soil. While NAPL is immiscible (incapable of being mixed) with groundwater, it is constantly dissolving when in contact with groundwater, and therefore represents a continuing source of groundwater contamination. NAPL that is less dense than water is referred to as a light non-aqueous phase liquid, or LNAPL. When an LNAPL, such as benzene, is released to the subsurface in sufficient quantity, it will generally migrate downward through the vadose zone until reaching the water table, where it will float and accumulate. NAPL that is denser than water is referred to as a dense non-aqueous phase liquid (DNAPL). When DNAPLs such as TCE and chlorobenzene are released to the subsurface in sufficient quantity, they will generally migrate downward through the vadose zone and penetrate the water table because of their greater density.

Downward migration of NAPL is retarded by low permeability layers in the subsurface, which may result in pooling of the NAPL on top of the layer. After a NAPL release has ceased, NAPL migration continues until further movement is prevented by low permeability layers and/or the NAPL has disseminated to the point where it is completely retained in the soil pore spaces by capillary forces.

NAPL saturation refers to the percentage of soil pore space that is occupied by the NAPL. NAPL at low saturations is often discontinuously present in the soil matrix, trapped within ganglia or stringers. NAPL at relatively high saturations may be perched on top of the water table (if LNAPL) or on low permeability layers (LNAPL or DNAPL). Higher NAPL saturations imply a greater potential for migration than lower saturations. When NAPL saturation decreases to the point where it is no longer capable of migrating, the NAPL is at *residual saturation*. Residual saturation refers to a range of values (for example, from 0-20%) over which the NAPL is immobile under existing hydrogeologic conditions. Many factors, including soil grain size and distribution, hydraulic gradient, and NAPL viscosity among others, affect NAPL mobility and the corresponding residual saturation range. Moreover, if one or more of these factors is changed through either natural processes or human activity, NAPL mobility can be either increased or decreased.

While LNAPL is commonly visualized as occurring in pools floating on top of the water table, it can also be present below the water table, despite the fact that it is lighter than water. This mode of occurrence exists when LNAPL has accumulated on top of the water table and the water table

rises. As the groundwater rises, it exerts an upward buoyant force on the LNAPL, but a portion of the LNAPL is held in the submerged pore spaces by capillary forces. Given sufficient increases in groundwater levels, the LNAPL will no longer exist as a floating pool, but instead within a “smear zone” that corresponds to the amount of rise in the water table. The LNAPL is typically present discontinuously within the smear zone at or near residual saturation levels. A long-term trend of rising groundwater (see Section 3.3.1) and LNAPL smear-zones (see Section 11.3.3 below) have both been documented at locations within the former plant site.

11.2 NAPL INVESTIGATIONS

Investigation of NAPL began in the vicinity of well MW-20, where LNAPL was known to be present based on its observation in fluid samples from the well. The LNAPL composition, source, modes of occurrence, and lateral and vertical extent were evaluated as part of the MW-20 Focused Investigation and MW-20 Source Area Investigation described in Section 4.3.1 and 4.3.2. The subsequent MW-20 Pilot Program (Section 4.3.3) evaluated the efficacy of NAPL removal through hydraulic extraction. Investigation of NAPL was subsequently expanded through the NAPL screening investigation, which evaluated NAPL conditions at three additional rubber plant areas. As stated in Section 4.3.13, the objectives of this investigation were to: (1) characterize the physical conditions and the nature of NAPL that may be present; and (2) evaluate whether conclusions regarding the effectiveness of NAPL remediation technologies at the MW-20 area can appropriately be applied to other areas of the former plant site where NAPL may be present. The methods used for both the MW-20 area and NAPL screening investigation efforts and the results are described in further detail in the ensuing subsections.

It is recognized that NAPL identification and delineation can be problematic for the following reasons:

- The minimum volume of NAPL that must be present to trigger the identification or reporting of NAPL is not known to have been established or widely accepted. Even very small releases of NAPL products will result in the presence of NAPL in soil pore spaces that remain until removal through dissolution, volatilization, and degradation processes. NAPL that is present at low (residual) saturation levels within the vadose zone is not readily distinguishable from soil contamination and is typically handled as such in the environmental industry.
- NAPL is often heterogeneously distributed over relatively small distances and different modes of occurrence. For example, NAPL may be present at high saturations within a pool that is perched on top of groundwater or impermeability layer where it can readily migrate into a well. Alternatively, the NAPL may only be discontinuously present at

low saturations, trapped in soil pores as ganglia and stringers, where it is immobile and incapable of entering a well. Because of the wide range of conditions in which NAPL can be present, NAPL may be readily observed at one location, but not observed at all at another, nearby location.

- There is no standard, “regulatory agency approved” test method for evaluating the potential presence of NAPL. While multiple NAPL identification methods are available, documented information regarding the relative sensitivity of the various NAPL identification methods was unknown at the time of the RI field investigations. Due to these potential sensitivity differences, NAPL identification by one method may not correlate with results from other methods.

To address the above difficulties, multiple methods were used in the RI to identify potential and confirmed NAPL areas. These methods are as follows:

- Direct observation of NAPL at groundwater monitoring locations;
- Comparison of dissolved (groundwater) VOC concentrations relative to compound-specific solubility limits;
- Evaluation of deep soil gas data;
- Rapid Optical Screening Tool (ROST) laser-induced fluorescence;
- Laboratory measurements of hydrocarbon saturation (Dean Stark testing);
- “Jar testing” of soil core; and
- Observation of ultraviolet (UV)-light induced NAPL fluorescence in soil core.

Further details regarding these methods and the findings for each are described below.

11.2.1 Direct Observation

The most straightforward method of NAPL identification is through direct observation of NAPL in fluid samples collected from groundwater monitoring locations (monitoring wells, temporary wells, or hydropunch locations). While providing direct proof of the presence of NAPL, the limitation of this method is that NAPL may be present in the subsurface but not enter the well if it is present at relatively low saturations or in discontinuous ganglia. Thus, even for an ideally located and constructed monitoring well, the absence of NAPL in fluid samples collected from the well does not necessarily indicate the absence of NAPL in the subsurface.

Areas where NAPL has been directly observed in groundwater monitoring locations are hereafter referred to as *NAPL accumulation areas*. This term is used to indicate that the NAPL present is capable of entering and accumulating in a well, but it is not otherwise intended to imply how the

NAPL occurs in the subsurface. NAPL accumulation areas are distinguished from other NAPL areas because remedial technologies may be considered in the FS for accumulation areas that would not be appropriate for other areas where NAPL is present but does not enter a well.

Through the direct observation method, a NAPL accumulation area was identified at the MW-20 area during the initial investigations of this area. A second NAPL accumulation area was identified within the butadiene plancor by this method during the NAPL screening investigations. The MW-20 area NAPL is inferred to be associated with VOC storage tanks that were formerly located in this area, while the butadiene plancor NAPL may be associated with a former laboratory and/or underground pipelines (Figure 57). These areas are discussed in more detail in Section 11.3.3 below.

11.2.2 Dissolved VOC Concentrations

Dissolved-phase VOC concentration data provided additional insight regarding the *potential presence* of NAPL when its presence and distribution were not already known through other methods. For LNAPL components such as benzene and ethylbenzene, LNAPL was identified as being potentially present when dissolved VOC concentrations were detected at 5% or more of their respective solubility limits¹⁰. Areas where DNAPL is potentially present were similarly evaluated, except that a more conservative value of 1% of solubility was applied, in accordance with USEPA methods (USEPA, 1992a). This more conservative guideline for DNAPL is appropriate in view of the greater potential for DNAPL to penetrate the water table, which often results in increasing dissolved concentrations with depth until the maximum depth of the DNAPL is reached.

The above 1% and 5% values are subjective guidelines, and were used only as an initial screening to indicate general areas where NAPL is *potentially* present. NAPL is expected to be present in only a small percentage of the total area where dissolved concentrations exceed the guideline values since concentrations immediately adjacent to NAPL would be at or near saturation and decrease with distance through diffusion, dispersion and other natural attenuation processes. Furthermore, NAPL is most likely to be found in proximity to its original release point due to retention within soil pore spaces as it migrates. Therefore, while the area where water table concentrations exceeded 1 or 5% of saturation forms a basis for identifying the *potential* presence of NAPL, the actual LNAPL area can be significantly refined from locations of groundwater concentration maxima, knowledge of former VOC facility locations where

¹⁰ For the previously completed Final Groundwater Remedial Investigation Report, evaluation of potential LNAPL areas through dissolved VOC concentrations was limited to benzene using a 100,000 µg/l criteria (5.6% of solubility). This method has been generalized here to include all VOCs at 5% of their individual solubilities (see Table 23).

releases may have occurred, and the use of other, more sensitive NAPL identification methods, as described in the sections below.

Evaluation of dissolved VOC concentrations was used in conjunction with historical rubber plant operations information to screen the former plant site for areas where NAPL is potentially present. Table 23 and Figure 57 summarize the areas of potential NAPL, where dissolved VOCs are present at concentrations in excess of the potential LNAPL and DNAPL solubility criteria described above. Benzene, ethylbenzene, and xylenes were the only VOC LNAPL components detected in groundwater at the former plant site at concentrations in excess of the 5% of solubility screening guideline. DNAPL components detected at concentrations in excess of their 1% of solubility guideline values within the former plant site were limited to chlorobenzene and PCE. Former plant site facilities as well as facilities unrelated to the rubber plant that may be associated with the NAPL screening guideline exceedances are noted in Table 23 and on Figure 57.

Areas where NAPL was most likely to be present based on evaluation of dissolved VOC data and historical plant operations were selected for further evaluation in the NAPL Screening Investigations, while also taking into consideration accessibility. The three areas selected for further investigation included the VOC tank farm area in the styrene plancor, the benzene feedstock pipeline area at the south end of the butadiene plancor, and the former laboratory/pipelines area near the eastern boundary of the butadiene plancor (Figure 57). These areas are also referred to as groundwater contamination source areas #6, #11, and #12, respectively, as discussed in Section 12. NAPL conditions at these three areas were further evaluated through the methods described below.

11.2.3 Deep Soil Gas Data

Deep soil gas data were collected as part of the MW-20 Focused Investigation (Section 4.3.1) and were limited to a transect of 12 sampling locations that started in the MW-20 area and extended southeastward through the former tank farm area. Benzene was detected at concentrations in excess of 10,000 ppmv at 10 of the 12 sampling locations positioned immediately above the water table, as presented in Section 6.2 and on Figure 29. While these data are limited and there are no established criteria for linking soil gas concentrations with LNAPL, the data are useful as an additional indication of the *potential* presence of LNAPL within the former tank farm area, as shown on Figure 57. This interpretation is based on the similarity between the highly elevated deep soil gas benzene concentrations detected at the MW-20 area, where LNAPL was directly observed, and the benzene concentrations detected within the tank farm area further southeast.

11.2.4 ROST

ROST testing is a field method wherein a laser-emitting probe is pushed through the subsurface, stimulating hydrocarbons present in the soil to fluoresce. The intensity of the fluorescence is recorded continuously with depth on the ROST profile. The intensity of the fluorescence typically increases with increased hydrocarbon content for a given hydrocarbon composition, although VOC concentrations and hydrocarbon saturation values cannot generally be calculated from the ROST data. For the purposes of this investigation, any observable deviation in the fluorescence profile above the background noise was inferred to correlate with the presence of NAPL.

Three ROST profiles were completed at both Source Area 11 and Source Area 12, while six ROST profiles were completed at Source Area 6 to evaluate the potential presence and distribution of NAPL. ROST was not utilized at the MW-20 NAPL accumulation area because the LNAPL present was already relatively well delineated through other methods. Evidence for the presence of NAPL was observed in one or more of the ROST profiles at each of the three NAPL screening areas. Further details regarding the ROST findings for each of these areas is presented in Section 11.3 below.

Cone penetrometer profiles were conducted coincident with the ROST profiles to obtain corresponding lithologic data.

11.2.5 Hydrocarbon Saturation Data

Dean-Stark testing for hydrocarbon saturations was completed in the laboratory for soil core collected from the MW-20 area and each of the three NAPL screening investigation areas. This test method measures the volume of hydrocarbon present relative to the total pore space volume present to derive the hydrocarbon saturation, which is presented as a percentage of the total pore space. The lower limit of saturation measurement is approximately 0.1%, and any positive measurement (i.e., $\geq 0.1\%$) was inferred to be an indication of the presence of NAPL.

Hydrocarbon saturation values are available from 17 soil borings from the MW-20 area, and from one boring in each of the three NAPL screening investigation areas. The abundance of samples tested in the MW-20 areas is due to the comprehensive nature of the investigation in that area and effort to fully delineate the lateral extent of the NAPL. NAPL testing within the remaining three NAPL screening investigation areas was more focused on evaluation of the vertical distribution of NAPL and its modes of occurrence. Thus, hydrocarbon saturation testing in these areas was limited to numerous samples from a single boring, which was located in the area of greatest hydrocarbon abundance, as indicated from the ROST profiles.

Hydrocarbon saturation data are summarized in Table 22 and comprehensively presented in Appendix F. Measurable hydrocarbon saturations were detected in a portion of the tested soil samples from each of the four NAPL investigation areas, confirming the presence of NAPL. Hydrocarbon saturation values for all samples ranged from 0 to 30%, but the vast majority of values were less than 5%. Centrifuge testing of soil samples from the MW-20 area indicated that residual saturation (non-mobile NAPL) conditions occur at saturations of 16% and less for fine to medium sand, and 50% and less for silt and clay (URS, 2003a). While some variation is expected in these values between locations, the vast majority of the measured hydrocarbon saturations within the former plant site are nonetheless inferred to reflect residual levels.

11.2.6 Jar Testing

Jar testing was conducted for soil core collected from the MW-20 area and each of the three NAPL screening areas. Initial jar testing completed at the MW-20 area involved mixing two-inch sections of soil core with tap water in a small jar along with “Sudan Red”, a hydrocarbon-specific dye in powder form. The dye preferentially stained NAPL that was present, enhancing its visibility. Since the MW-20 area was a previously known NAPL accumulation area, the jar testing was primarily a method of documenting the lateral and vertical distribution of NAPL. Jar testing was completed for core from 10 soil borings in the MW-20 area, with results being recorded as either positive (NAPL present) or negative (NAPL not observed), as documented in the logs presented in Appendix F. The results indicated that the MW-20 LNAPL distribution was highly variable and intermittent within an approximately 30-foot thick smear zone under the water table. The MW-20 LNAPL area is further described in Section 11.3.3 below.

Jar testing at the remaining three NAPL screening investigation areas was conducted several years after the MW-20 testing, incorporating a refined technique that omitted the Sudan Red dye. The soil core was carefully and gradually disaggregated in the tap water while making visual observations with a light reflecting off the water surface toward the viewer. Following this procedure, hydrocarbon sheens and minute traces of NAPL could be observed; very small NAPL droplets were sometimes visible for only a few seconds or less before dissolving into the water. In contrast, minute NAPL traces were often overwhelmed and obscured when the powder dye was used, decreasing the sensitivity of the test.

The refined jar testing technique was completed for continuous soil core from one boring at each of the three NAPL screening investigation areas. The locations of the jar-testing borings were selected to coincide with the ROST profile locations that exhibited the most extensive hydrocarbon signature. These jar test results, along with the ROST and other test methods, allowed interpretation of the vertical distribution and modes of occurrence of the NAPL in each of the three NAPL screening investigation areas.

Jar testing results for the NAPL screening investigation are included in Appendix F, and indicate an intermittent, heterogeneous NAPL distribution within the saturated and vadose zones at each of the three NAPL screening areas. Moreover, comparison of the NAPL Screening area jar testing results with laboratory hydrocarbon saturation results for co-located samples (see hydrocarbon logs in Appendix F) shows that NAPL saturations of 1% and less were consistently observed through jar testing and that traces of NAPL were often observed when laboratory-derived hydrocarbon saturation values were below measurable limits (<0.1%). While there is a potential for observational errors when very small amounts of NAPL or no NAPL is present, the data suggest that jar testing is likely more sensitive to the presence of NAPL than the laboratory measurements of hydrocarbon saturation (Dean Stark testing).

The jar testing data further indicate that the observed presence of NAPL does not always correlate with high contaminant concentrations, as determined by laboratory VOC/SVOC analysis of soil samples. For example, hydrocarbon saturation testing, NAPL jar testing, and VOC analytical data are available from approximately 12 feet bgs at boring SBL0125 (VOC tank farm area, styrene plancor) where the ROST profile indicated abundant hydrocarbon. Jar testing indicated the presence of NAPL, and laboratory-measured hydrocarbon saturation values ranged from 0.13 to 2.24%. However, VOC/SVOC testing of the soil indicated the presence of only modest concentrations of contaminants: ethylbenzene at 37 mg/kg, sec-butylbenzene at 1 mg/kg, and dibutylphthalate at 0.33 mg/kg. When samples had higher hydrocarbon saturation values (for example, 13.69% for the sample from boring SBL0123 at 27 feet bgs), soil testing did show the expected substantial increases in contaminant concentrations (total BTEX at 153 mg/kg, and unidentified C10-C23 compounds at 3,720 mg/kg) that are more typically associated with NAPL presence.

11.2.7 UV-light Induced Fluorescence

Some NAPL will fluoresce when stimulated by UV-light, depending on composition. Benzene LNAPL will fluoresce, although it is relatively weak and can be difficult to observe, especially when the NAPL is present at relatively low saturations and obscured within a soil matrix. Soil core from borings in each of the four NAPL investigation areas was observed under UV light and results are documented in the hydrocarbon logs presented in Appendix F. For the purposes of this investigation, any observation of fluorescence was interpreted as evidence for the presence of NAPL.

Fluorescence was intermittently observed within soil core at each of the four areas where NAPL was investigated. Fluorescence observations generally correlated well with measurable

hydrocarbon saturations and jar testing results showing obvious indications of NAPL, but was typically not observed where jar testing indicated NAPL presence at only trace levels.

11.3 NAPL AREAS

Considering the above findings, the former plant site was separated into four categories with respect to NAPL:

- (A) **Areas where NAPL has not been observed or measured and is not suspected** based on relatively low dissolved phase contaminant concentrations in groundwater.
- (B) **Areas where NAPL is potentially present, but has never been observed or measured.** NAPL was judged to be “potentially present” where individual dissolved VOC concentrations were $\geq 5\%$ of their respective solubility limits for LNAPL components and where $\geq 1\%$ of their solubility limit for DNAPL components. NAPL was also judged to be potentially present where deep soil gas (immediately above the water table) VOC concentrations were similar to concentrations detected in an area of known NAPL. Further discussion of the areas meeting these criteria is presented in Section 11.3.1 below.
- (C) **Areas where NAPL is present, but at residual (non-mobile) saturations,** as evident from soil core jar testing, laboratory measurements of hydrocarbon saturations, and the lack of any direct observation of NAPL accumulation at groundwater monitoring locations. Saturations of less than 16% are inferred to be indicative of residual levels, based on data presented in the MW-20 Pilot Program Report (URS, 2003a). All areas meeting these criteria lie entirely within a larger, potential NAPL area, as described in “B” above. Further discussion of residual saturation NAPL areas is presented in Section 11.3.2 below.
- (D) **Areas where NAPL accumulations occur, as indicated by direct observation of fluid samples from a monitoring well or temporary well point.** This occurrence is distinguished from categories A, B and C above since remediation by direct NAPL removal techniques (NAPL pumping or bailing) will be evaluated as part of the FS process. NAPL accumulation areas are discussed in further detail in Section 11.3.3 below.

Rubber plant areas corresponding to the categories B, C, and D above are indicated on Figure 57. NAPL accumulations are present only at the MW-20 area (near the western boundary of the

former plant site) and at Source Area 12 (in the vicinity of the former butadiene plant laboratory and adjacent underground pipelines, near the eastern boundary of the former plant site). NAPL accumulations observed at the latter area were very small (less than ¼ inch within a sample bailer).

The salient aspects of each NAPL area are summarized below. Comprehensive NAPL saturation (Dean Stark analysis) data for each NAPL area are presented in Appendix F and are summarized in Table 22. Hydrocarbon logs for each NAPL area, including soil types and corresponding jar testing results, ultraviolet light observations, ROST profiles, CPT profiles, hydrocarbon saturation data, and soil contaminant analytical data are also included in Appendix F. Groundwater data relevant to each NAPL area are summarized in Table 23.

Further details regarding confirmed NAPL areas are available within the MW-20 Focused Investigation report (D&M, 1993b), the NAPL Screening Investigation report (D&M, 1998b), the MW-20 Pilot Program report (URS, 2003a), the Final Groundwater RI Report (D&M, 1998a), and the dual site (Montrose Chemical and Del Amo Superfund Sites) ROD for the groundwater operable unit (USEPA, 1999a). Groundwater data being generated as part of groundwater remedial design work currently in progress for the dual site may also be considered by EPA in developing the Proposed Plan and the ROD for the Soil and NAPL operable unit.

11.3.1 Potential LNAPL and DNAPL Areas

Table 23 and Figure 57 summarize the areas at which dissolved VOCs were found at concentrations in excess of the previously described 5% and 1% of solubility guidelines for identifying potential LNAPL and DNAPL, respectively. An area of potential LNAPL surrounds each of the areas of confirmed LNAPL.

The area of potential LNAPL in the former styrene plant extends through the vicinity of a styrene finishing/benzene purification unit, two ethylbenzene production units, and utility storage tanks. Subsurface investigations to evaluate LNAPL conditions in the vicinity of these former facilities were not completed, based in part on their limited accessibility. While differences in LNAPL extent may exist between areas, the findings for the confirmed LNAPL areas (LNAPL accumulation areas and areas where LNAPL has been observed at residual saturations) are inferred to also be applicable to the uninvestigated potential LNAPL areas and are sufficient to proceed with development and evaluation of remedial alternatives for LNAPL in the FS. This is further discussed in Section 11.3.4 below. A ROD has been previously issued for the remaining area of potential LNAPL in the vicinity of the Waste Pit Area (USEPA, 1997).

DNAPL components present at concentrations in excess of the 1% of solubility guideline within the former plant site include chlorobenzene and PCE. Monitoring locations where dissolved concentrations exceeded the DNAPL screening criteria occurred at monitoring wells XMW-13 (chlorobenzene) and PZL0016 (PCE). Well XMW-13 is located in the southwestern corner of the former plant site, while PZL0016 is located further north, along the western plant boundary of the former plant site (Figure 54). Both wells lie adjacent to, or near, facilities west of the former plant site that are known source areas for the compounds of concern. Chlorobenzene is associated with the Montrose superfund site, and is known to be present in DNAPL at that site (USEPA, 1998). PCE is associated with the American Polystyrene Corporation (formerly AMOCO Chemical Corporation) and PACCAR Inc. (formerly Trico Industries) properties, which are both currently being investigated under the oversight of the California Regional Water Quality Control Board, in cooperation with USEPA.

11.3.2 Residual LNAPL Areas

Styrene Plancor - VOC Tank Farm LNAPL

The LNAPL southeast from the MW-20 area was only observed at trace amounts, preventing collection and analysis of a NAPL sample to directly determine its composition. However, laboratory results for shallow soil samples (boring SBL0125), both shallow and deep soil gas samples (locations SGL0036 and SGL0034, among others) and groundwater (water table monitoring well XMW-21) from this area collectively indicate the NAPL is likely composed of benzene and ethylbenzene. The NAPL is inferred to be associated with releases from the former aboveground VOC storage tanks that were part of the tank farm near the western margin of the styrene plancor, as shown on Figure 57.

ROST profiles for the area show a hydrocarbon signature that is greatly reduced relative to other NAPL areas, and that is almost entirely limited to the vadose zone. Jar testing observations and hydrocarbon saturation tests were consistent with the ROST findings, and show the maximum hydrocarbon at approximately 10 to 14 feet bgs at SBL0125. The maximum hydrocarbon saturation in this interval was 2.24%, and correspond with laboratory VOC data indicating an ethylbenzene concentration of only 37 mg/kg. Trace indications of hydrocarbon were observed throughout much of the remainder of the vadose zone, mostly at non-detectable levels of hydrocarbon saturation. Trace NAPL occurrences are much less frequent within the saturated zone, but continue sporadically to near the maximum depth of the soil boring at 90 feet bgs. NAPL saturation data range from 0 to 2.2% (Table 22), with an average value of 0.4%. The lateral extent of the LNAPL is inferred to be limited to the immediate vicinity of the VOC storage tanks. ROST, hydrocarbon saturation, and observational NAPL testing data from boring SBL0125 in the tank farm area are collectively summarized in a hydrocarbon log in Appendix F.

Butadiene Plancor - Benzene Feedstock Pipeline LNAPL

The LNAPL believed to be associated with the former benzene feedstock pipeline is known to be present based on soil core jar-testing observations and laboratory hydrocarbon saturation measurements. NAPL was not observed in quantities sufficient to permit exclusive sampling and laboratory analysis. The NAPL is inferred to be composed primarily of benzene based on analyses of numerous soil and groundwater samples completed as part of RI and non-RI investigations. The NAPL most likely originates from a leak in the pipeline that was used during the operational period of the rubber plant. The approximate location of the pipeline in the vicinity of the LNAPL is indicated on Figure 57.

ROST profiles from the area show an intermittent hydrocarbon distribution from near surface to approximately 85 feet bgs. Pronounced hydrocarbon signatures from 10 to 20 feet bgs within the vadose zone, and from approximately 50 to 75 feet bgs within the saturated zone, are apparent in two of the three ROST profiles for the area. While the lateral extent of the LNAPL has not been fully evaluated, the dissolved benzene concentrations attenuate abruptly with distance, suggesting that the LNAPL is limited to the immediate vicinity of the benzene pipeline source area. A hydrocarbon log summarizing ROST, hydrocarbon saturation, and observational NAPL testing data for boring SBL0124 in the benzene feedstock pipeline area is presented in Appendix F.

11.3.3 LNAPL Accumulation Areas**MW-20 LNAPL**

The MW-20 LNAPL is composed almost entirely (>95%) of benzene and extends laterally over an area of approximately 19,500 square feet, based on field and laboratory observations from monitoring wells and soil borings. The comprehensive investigation of NAPL conditions completed for the MW-20 Pilot Program (URS, 2003a) and other investigations confirms that the LNAPL is present in only a limited portion of the “5% of solubility” area shown on Figure 57. Measurable accumulations of LNAPL have been consistently observed at monitoring wells XMW-20, SWL0001, and SWL0032 in the area during groundwater monitoring events completed on an at least annual basis between 1993 and 2000.

Observational and hydrocarbon saturation data for the MW-20 area indicate LNAPL at the MW-20 area is discontinuously present within an approximately 30-foot smear zone extending downward from the water table, from approximately 60 to 90 feet bgs. This NAPL smear zone is inferred to have been created by a rising water table after LNAPL accumulated on the water table. A portion of the NAPL rose with the water table, but some was retained in the soil pore spaces by capillary forces, resulting in the observed NAPL smear zone. Laboratory NAPL

saturation values for the MW-20 NAPL area range from <0.1 to 30%, with an average value of 2.4% (Table 22).

A pilot hydraulic extraction program was completed within the MW-20 NAPL area to evaluate the feasibility of NAPL recovery, as described within the MW-20 Pilot Program report (URS, 2003a). Approximately 1.2 million gallons of groundwater were pumped from a portion of the NAPL area over a period of seven months. Separate phase NAPL recovery during this period was limited to approximately 36 gallons, while an additional 1,420 gallons of benzene were recovered in the dissolved phase. While NAPL distribution within the smear zone is known to be heterogeneous, comparison of pre- and post-hydraulic extraction soil core showed no significant reduction in the subsurface NAPL distribution or hydrocarbon saturation values.

Butadiene Plancor Laboratory LNAPL

Identification of the butadiene plancor laboratory LNAPL accumulation is based on one-time (September 1997) observation of a thin (<1/4-inch) layer of NAPL in groundwater samples collected from near the water table (between 40 and 43 feet bgs) at temporary well points CWL0051 and CWL0054. The volume of LNAPL present was insufficient for sampling and direct laboratory analysis; therefore, the LNAPL composition was inferred from groundwater (temporary well point CWL0051) and soil boring (SBL0123) samples. High concentrations of benzene (260,000 µg/l), toluene (75,000 µg/l), ethylbenzene (4,000 µg/l), xylenes (22,000 µg/l), and styrene (17,000 µg/l) were detected in groundwater and are therefore inferred to be components of the LNAPL. The LNAPL may also include many additional compounds detected in soil core, including cyclohexane, naphthalene, 1,2,4-trimethylbenzene, 2-hexanone, methylisobutylketone, sec-butylketone, sec-butylbenzene, phenanthrene, pyrene, dimethylphthalate, and numerous unidentified compounds in the C10-C23 range. The lack of detection of these compounds in the groundwater samples that contained the visible LNAPL is inferred to be due to elevated detection limits and/or low solubilities.

The possibility of butadiene in the NAPL and surrounding groundwater cannot be ruled out; however, butadiene is a gas under standard temperature and pressure conditions and thus would rapidly volatilize from solutions released to the environment. For this reason, butadiene is unlikely to be a significant component of the LNAPL. The potential presence of butadiene in groundwater was evaluated in 2000 using a specially developed laboratory analytical method to achieve detection limits at or near tap water PRG values (there are no MCLs for butadiene). Data from the evaluation was subsequently rejected based on USEPA's quality assurance concerns regarding the laboratory method, and is therefore excluded from the RI database.

The origin of the LNAPL is not known with certainty. Former facilities closest to the area of known LNAPL are the butadiene plancor laboratory building and multiple underground pipelines, but details regarding the use of these facilities and their waste products are not known.

A hydrocarbon log for boring SBL0123 presented in Appendix F summarizes ROST, observational NAPL data, and laboratory derived hydrocarbon saturation data in the vicinity of the former butadiene plancor laboratory. These data indicate the LNAPL is discontinuously present in both the vadose and saturated zones, extending to a depth of at least 85 feet bgs. The vertical distribution of the LNAPL below the water table indicates the presence of an LNAPL smear zone, similar to that observed for the MW-20 NAPL area. As previously discussed, this mode of occurrence is associated with a rising groundwater table.

Measured NAPL saturations range from 0 to 13.7% (4% average), and are thus inferred to be at residual levels. The lateral extent of residual LNAPL is interpreted to be a fraction of the local “5% of solubility” area shown on Figure 57.

11.3.4 Comparison of NAPL Investigation Findings

NAPL conditions at the MW-20 area were investigated as part of the MW-20 Focused Investigation, the MW-20 Source Area investigation, and the MW-20 Pilot Program. NAPL conditions at three additional plant site areas (source areas #6, #11, and #12) were investigated as part of the NAPL Screening Investigations. Findings from these investigations indicate the following similarities:

- LNAPL is present in each of the investigated areas, with benzene and/or ethylbenzene being the primary component(s);
- The LNAPL is present within the UBF, MBFM (where present) and MBFB hydrostratigraphic units, which are relatively fine grained sediments (silt and sandy silt) interbedded with fine sand;
- The LNAPL is discontinuously present in the subsurface within a smear zone that is attributed to a rising water table interacting with the LNAPL; and
- Hydrocarbon saturations are generally relatively low (average saturation at each area is \leq 4%), indicating residual saturation levels (unable to migrate under existing conditions).

These findings are additionally expected to be true for other plant site areas where LNAPL may be present since (1) lithologic conditions across the plant site are relatively consistent (interbedded silt and fine sand; see Section 3 and Figures 14 through 17) and (2) the rising groundwater table that results in a NAPL smear zone and associated heterogeneous NAPL distribution at mostly residual saturations is a regional phenomenon that has affected the entire

former plant site. Therefore, while the potential presence and extent of LNAPL has not been fully evaluated at all plant site areas where it is suspected, the findings are sufficient to permit development and evaluation of LNAPL remedial alternatives in the FS that are applicable to the entire plant site. Depending upon the nature of the NAPL remedy ultimately selected in the ROD, additional delineation of NAPL areas can be completed during remedial design, as appropriate.

11.4 NAPL CONCLUSIONS

Recognizing the inherent limitations in NAPL investigations, conclusions regarding the NAPL investigative techniques used in this RI and the findings for the former plant site NAPL areas are summarized as follows:

- (1) Very small volumes of NAPL within the soil matrix were detectable. Jar testing is judged to be the most sensitive of the techniques used in this RI, although it relies on careful observation and is therefore subject to some error.
- (2) The presence of NAPL does not always correspond with high contaminant concentrations in soil. Relatively low contaminant concentrations (less than 40 mg/kg total) were measured when NAPL was present at saturations of several percent or less. Much higher concentrations were found when the NAPL saturation was much higher (above 10%).
- (3) When present within the vadose zone and at residual saturations, NAPL is not readily distinguished from soil contamination, and is typically referred to and handled as such within the environmental industry. Such vadose zone soil contamination is known to be present at several areas investigated at the former plant site.
- (4) LNAPL is discontinuously present within a smear zone beneath the water table at some rubber plant areas. This mode of occurrence has resulted from the downward migration of past LNAPL releases and a water table which has been consistently rising since the 1960s. While some of NAPL rose with the buoyant force of the rising water, a portion of it was held in soil pore spaces by capillary forces, producing an LNAPL smear zone below the water table.
- (5) Pools of LNAPL floating on top of the water table have not been observed at the former plant site. The LNAPL has typically been observed in smear zones, which are inferred to have been created by the rising water table conditions that have existed in the vicinity of the former plant site since approximately 1965. "NAPL accumulation areas", where NAPL is present at saturations sufficient to enter a well, are known to be present at the MW-20 NAPL area (groundwater contamination source area #3) and at the former butadiene plancor laboratory NAPL area (source area #12). LNAPL is

- additionally known to be present at residual saturations in the subsurface at source areas #6 and #11, but it has not accumulated within any temporary or permanent well screens in these areas.
- (6) DNAPL has not been observed, although dissolved concentration data indicate it could potentially be present in the southwestern corner of the former plant site (chlorobenzene) or further north, along the western boundary of the rubber plant (PCE). Sources for chlorobenzene and PCE exist to the west of the former plant site, in close proximity to these respective areas.
 - (7) Laboratory testing of soil core from the MW-20 area indicates that residual saturation levels occur from 0 to 16% for fine to medium sand, and from 0 to 50% for silt and clay (URS, 2003a). Based on this finding, the vast majority of the hydrocarbon saturation data for the former plant site are at residual levels, unable to migrate under current conditions.
 - (8) NAPL remedial alternatives for the MW-20 area and groundwater contamination source areas #6, 11, and 12 will be developed and evaluated in the FS and can appropriately be applied to other potential LNAPL areas at the former plant site. This conclusion is based on the similarity in the subsurface lithology across the former plant site and the similarities in NAPL composition and distribution in the areas of known NAPL.

Collection and evaluation of groundwater data from the former plant site is ongoing as part of Groundwater Remedial Design activities. While not presented here, Groundwater Remedial Design data may additionally be taken into consideration by EPA in development of the Soil and NAPL ROD, to the extent that they change the understanding of the nature and extent of NAPL at the former plant site.

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12.0 GROUNDWATER CONTAMINATION SOURCE AREAS

Groundwater contamination source areas (hereafter referred to as “source areas”) are areas where past releases of contaminants are inferred to have migrated downward through the vadose zone and impacted groundwater to the extent that Cal MCLs are consistently exceeded. Rubber plant source areas have been identified based on the following lines of evidence:

- Areas of groundwater contamination in close proximity to former plant site facilities where large volumes of chemicals were stored, processed, or disposed;
- Evidence of vadose zone contamination, including elevated contaminant concentrations in shallow soil gas or soil, and/or the observed presence of LNAPL;
- Water table analytical data indicating elevated concentrations of compounds relative to surrounding monitoring locations;
- A correspondence or link between the chemicals present in the vadose zone, those known or likely to have been present at the historical facility, and the specific components of the groundwater contamination or NAPL.

Twelve source areas at the former plant site have been identified through a synthesis of historical facility information, soil and soil gas data, and NAPL and groundwater (water table) conditions described in previous sections and application of the above guidelines. These source area locations are shown on Figure 58 and are identical to those previously presented in the Groundwater RI (D&M, 1998a). An overview of conditions at each source area is provided in the table below and included on the figure.

Source Area Number	Plancor	Suspected Source Facility	Primary Contaminants	NAPL?
1	Copolymer	VOC storage tanks	Cyclohexane	Unlikely
2	Copolymer	Properties to the west of the former plant site	TCE, PCE	Potential DNAPL
3	Styrene	VOC tanks	Benzene	LNAPL accumulation
4	Styrene	Styrene finishing/benzene purification unit	Benzene, cyclohexane	Potential LNAPL
5	Styrene	Styrene finishing/benzene purification unit	BTEX, styrene	Unlikely
6	Styrene	VOC tank farm	Benzene, ethylbenzene	Residual LNAPL
7	Styrene	Ethylbenzene production units #1 and #2	Benzene, ethylbenzene	Potential LNAPL
8	Styrene	Ethylbenzene production units #1 and #2	Benzene, ethylbenzene	Potential LNAPL
9	Styrene	Utility tanks	Benzene, toluene	Potential LNAPL
10	Styrene	Waste pit area	BTEX	Potential LNAPL
11	Butadiene	Benzene feedstock pipeline	Benzene	Residual LNAPL
12	Butadiene	Laboratory and pipelines	BTEX, styrene	LNAPL accumulation

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Most of the source areas correspond with shallow soil or soil gas screening criteria exceedance areas previously discussed in Section 8. The areas common to both categories are as follows:

- Source area #2/ Pits and Trenches
- Source area #3 / VOC Storage Tanks (MW-20 NAPL area)
- Source area #4 / Styrene Finishing/Benzene Purification Area
- Source area #5 / Styrene Finishing Unit
- Source area #6 / VOC Tank Farm
- Source area #8 / Ethylbenzene Production Unit #2
- Source area #9 / Utility Tanks
- Source area #11 / Benzene Feedstock Pipeline
- Source area #12 / Laboratory and Pipelines

Source area #3 (the MW-20 LNAPL) has been extensively investigated, as described in the MW-20 Focused Investigation (D&M, 1993b), and the MW-20 Pilot Program Report (URS, 2003a).

With the exception of source areas #1 and #2, the identified source areas are all associated with elevated concentrations of dissolved benzene and ethylbenzene. Source areas #1 and #2 are associated with cyclohexane and TCE/PCE, respectively. A variety of other compounds are also present at some source areas, as indicated in the above table.

The 2003 Addendum Investigation was completed after the 12 groundwater contamination source areas were first identified. However, the data from that investigation were taken into consideration in evaluating whether additional groundwater contamination source areas (more than the original 12 identified) may exist, as described below. The 2003 addendum data were previously presented as part of the larger group of all shallow soil data in Section 7.2, but are independently summarized on Figure 59 and in this discussion for evaluation of source areas. The sampling locations are color coded on the figure to indicate where screening criteria exceedances for VOCs, PAHs, pesticides, and metals occur.

As indicated on Figure 59, VOCs were detected at concentrations in excess of PRGs at four areas, including an area at the western boundary of the former plant site, along two areas adjacent to the current Magellan Drive, and near the intersection of Knox Street and Hamilton Avenue. These areas correspond to the former “pits and trenches” area in the southern copolymer plancor, ethylbenzene production and styrene finishing process areas in the styrene plancor, and a waste water treatment area in the northern butadiene plancor. The first three of these are at previously identified source areas #2, #5, and #8 (Figure 58). The fourth area is not judged to be a source area since the soil sampling location where benzene and ethylbenzene were detected at

12.0 GROUNDWATER CONTAMINATION SOURCE AREAS

elevated concentrations is outside of the benzene and ethylbenzene dissolved plume area; that is, the detected VOC soil contamination in the waste water treatment area has not impacted the water table (see benzene and ethylbenzene dissolved plumes on Figures 55 and 56).

PAHs were detected in excess of their screening criteria at multiple areas, but are not nearly as likely to be associated with groundwater contamination as VOCs due to their relatively limited mobility and solubility. Moreover, the most recent (2000) groundwater data for the water table zone indicates PAHs have not been detected at concentrations in excess of existing Cal MCLs.

The supplemental shallow soil investigation also indicated a few areas where either metals or pesticides (DDT) exceeded their screening criteria. However, these contaminants have a low potential to impact the water table under normal conditions since they have low solubilities, they are relatively immobile, and groundwater is typically present at 50 feet or more bgs. For these reasons, it is very unlikely that the areas of shallow soil DDT and metals contamination identified in the 2003 Addendum Investigation will impact groundwater.

In summary, data from the Supplemental Shallow Soil Investigation have resulted in identification of multiple areas of soil contamination at the former synthetic rubber plant, some of which correspond with source areas previously identified in the Groundwater RI report. However, the data do not support the identification of additional groundwater contamination source areas beyond the twelve areas previously identified.

13.0 CONTAMINANT FATE AND TRANSPORT

This section presents an evaluation of the fate and transport of chemicals of potential concern (COPCs) at the former plant site. The discussion is focused on identifying potential contaminant migration pathways and evaluating the potential for transport of COPCs from contaminated media to locations where receptors may become exposed. This discussion establishes a framework for a more quantitative evaluation of chemical fate and transport in the BRA (Geosyntec & URS, 2006).

This section provides a general discussion of chemical transport and fate processes, and also describes more specifically how applicable transport and fate processes apply to COPCs at the former plant site.

13.1 FATE AND TRANSPORT PROCESSES

The fate and transport of COPCs within and between environmental media is governed by physical, chemical, and biological processes. An overview of the key processes involved is presented below.

13.1.1 Intermedia Transfers

Chemicals in the environment are distributed into solid, liquid and gas phases according to their specific properties and the existing environmental conditions. Environmental media that could be affected by chemical pollutants released into the environment include soil (solid phase); soil pore water and groundwater and NAPL (liquid phase); and soil gas and indoor/outdoor air (gas phase). Intermedia transfer is the movement of chemicals between these different media and phases, examples of which include (1) leaching of chemicals bound to soil into groundwater; (2) emissions of volatile chemicals from soil into air; and (3) dissolution of NAPL into soil pore water and/or groundwater. Intermedia transfer processes may apply at both the macro and micro levels. For example, soil can be considered as a single medium (phase) on the macro-scale, with potential chemical transfer to air, surface water, groundwater, and terrestrial or aquatic biota. On the micro-scale however, soil can be subdivided into solid soil particles, soil gas, and soil moisture, with transfer of chemicals occurring between these phases. Specific properties that influence the degree of intermedia transfer that occurs are discussed below.

13.1.2 Physical Transport

Soil

Transport of chemicals within soil occurs through several processes. Leaching occurs when soil contaminants dissolve into soil pore water and then migrate. The primary direction of leachate migration is typically downward, although lateral movement also occurs, especially when barriers to vertical migration are encountered. Transport also occurs through entrainment of colloidal particles with adhered chemicals in soil pore water. Colloids are very small particles (approximately 10^{-7} to 10^{-5} cm) that can remain suspended indefinitely. The entrained particles follow the bulk fluid flow patterns in the soil. A third transport mechanism involves NAPL, which can enter and migrate through soil in a manner similar to soil pore water. NAPL and soil pore water compete for the same pore space, and therefore each influences the flow paths of the other.

Chemical migration out of unsaturated soil can occur when leachate or NAPL intercept the water table, when volatile chemicals are emitted to the atmosphere, and when contaminated particulates from surface soil are entrained into the atmosphere.

Air

Air transport occurs through entrainment of chemical vapors or particulates in the atmosphere and the processes of advection and dispersion. Intermedia transfer of chemicals out of the air can occur through precipitation and deposition. Entrainment of contaminated particulates is minor since the former plant site is almost entirely covered with pavement and landscaping.

Groundwater

Transport of chemicals dissolved in groundwater occurs through advection, dispersion, and to a lesser extent, diffusion. Advection is flow in response to a hydraulic gradient. Dispersion is the mixing of groundwater that occurs due to the tortuosity of the flow pattern in the pore spaces around the soil particles. Diffusion is molecular transport of solutes from areas of higher concentration to lower concentration.

NAPL is transported in groundwater by capillary forces and buoyancy effects associated with density differences between the NAPL and groundwater. LNAPL is less dense than water and tends to float on top of groundwater, while DNAPL is denser than water and tends to migrate downward through groundwater under gravity. Despite the tendency to float on top of groundwater, LNAPL can still be submerged below the water table, as is the case at the former plant site. This occurs due to capillary forces and other NAPL trapping mechanisms in conjunction with a rising water table, as further described in Section 11.1.

Chemical transport out of groundwater can occur through volatilization into soil gas or the atmosphere, or groundwater discharge to the surface. Groundwater discharge to the surface does not occur at the former plant site.

Surface Water

Transport of chemicals within surface water occurs through advection and dispersion of solutes, suspended solids, and colloids. Intermedia transfer can occur if the surface water infiltrates into the subsurface, or through emission of volatile chemicals. Surface water transport is not judged to be a contaminant transport mechanism at the former plant site because: (a) there are no rivers, creeks, or other natural bodies of surface water present; (b) there is limited precipitation (average annual local rainfall is approximately 14 inches); and (c) the former plant site is almost entirely developed and covered by pavement and landscaping, limiting contact between any surface water and underlying soil.

13.1.3 Chemical and Biological Interactions

Chemical interactions that affect the transport of chemicals in soil, groundwater, and surface water include dissolution, sorption, and retardation. Dissolution pertains to a chemical (solute) dissolving into a solution (solvent), typically groundwater or surface water. The quantity of the chemical that can dissolve before reaching saturation is dependent on the specific physical properties of the chemical and the solvent, and the environmental conditions present.

Sorption processes include adsorption, chemisorption, absorption, and ion exchange. In adsorption processes, chemicals in the gas or liquid phase bind to a solid surface through electrostatic forces. Chemisorption is a similar process, but involves chemical reactions rather than electrostatic forces. Absorption occurs when chemicals diffuse into solid materials and bind to interior surfaces. Ion exchange is a process where mobile, electronically charged dissolved constituents replace electronically charged chemicals that are bound to solid particles.

Retardation occurs during flow in porous media when solutes move more slowly than the water that is transporting them due to sorption interactions.

Chemical interactions that affect air transport pertain to how the chemicals become associated with gasses and solid particles, the buoyancy of vapors, and the deposition of particulates. These processes are complex and governed by physical chemistry and thermodynamic factors that are beyond the scope of this document.

13.0 CONTAMINANT FATE AND TRANSPORT

Chemical interactions that affect the fate of chemicals in soil, groundwater, surface water, and air include transformations and sorption. Transformations are biologically or chemically mediated reactions that convert a chemical into a different chemical. Biologically mediated transformations are referred to as biodegradation. Transformations decrease concentrations of the original chemical and increase concentrations of the new chemical. The new chemical may be either more or less toxic, persistent, or mobile than the original chemical. The tendency for a chemical to transform is inversely proportional to chemical persistence. However, mobility is also linked to chemical persistence in the sense that concentrations in a given area will similarly decrease with migration away from the area, even if no chemical transformations have occurred. Similarly, sorption tends to increase persistence by binding chemicals at a particular location.

13.2 SITE-SPECIFIC FATE AND TRANSPORT

Site-specific evaluation of chemical fate and transport is important for understanding the degree to which COPCs are able to be transported from contaminated media (i.e., primary and secondary sources) to locations where receptors may become exposed.

13.2.1 Chemicals of Potential Concern

COPCs for the former plant site were developed as part of the risk assessment process using data presented in this RI report. COPCs were selected based on detection prevalence and comparison to toxicity screening criteria (PRGs), and for metals and PAHs, additional comparison to background values. The results of the COPC selection process are presented in Appendix C of the BRA (Geosyntec & URS, 2006). Major chemical classes in the COPC lists include VOCs, SVOCs/PAHs, pesticides, and metals. For the purposes of this discussion, representative chemicals for each chemical class are as follows:

Analyte Class	Representative Chemical
VOCs	Benzene Ethylbenzene TCE
SVOCs/PAHs	Benzo(a)pyrene
Pesticides	DDT
Metals	Arsenic

These representative chemicals were selected based on the frequency at which they were detected at concentrations in excess of their screening criteria in shallow (≤ 15 ft) soil.

13.2.2 Mobility, Persistence, and Degradation

The environmental behavior of chemicals can be estimated using mathematical models. Governing equations for chemical fate and transport take into account chemical mobility and persistence. Solubility, sorption, and volatility relate to mobility, while chemicals with long degradation times are described as persistent.

The principal properties related to chemical mobility are the aqueous solubility, sorption, and volatility related variables. Multiple sorption parameters are in common use, including the distribution coefficient (Kd), the octanol-water partition coefficient (Kow) and the organic carbon partition coefficient (Koc). The volatility of a chemical is typically expressed in terms of the vapor pressure (Vp) and Henry’s Law constant (Hc). Higher solubility and volatility imply a greater potential for migration. Sorption is inversely proportional to solubility, and therefore implies greater retardation and a decreased potential for migration, other factors being equal.

Degradation processes that affect persistence include biodegradation hydrolysis, and photolysis. Degradation is typically characterized in terms of various kinetic rate constants (e.g., half-life, k_{deg}). Chemical-specific values for these properties are tabulated within the BRA.

Broad generalizations regarding the above variables for the major chemical classes and representative COPCs at the former plant site are indicated in the table below. The high-medium-low values presented below are intended only as relative terms for comparison of the indicated representative chemicals and do not reflect any quantitative value or range of values.

Chemical Class and Primary COPCs	Solubility	Sorption	Volatility	Persistence
VOCs (benzene, ethylbenzene, TCE)	Medium To High	Low To Medium	High	Low To High
SVOCs/PAHs (benzo(a)pyrene)	Low	High	Low To Medium	Medium
Pesticides (DDT)	Low	High	Low	High
Metals (arsenic)	Low To Medium ¹¹	Medium To High ¹⁰	Low	High

Based on their relatively higher solubility and volatility, and relatively lower sorption, the representative VOCs for the former plant site are considered more mobile than the SVOCs/PAHs and pesticides, and probably more mobile than the metals. The pesticides and metals are less

¹¹ Generalizations regarding the solubility and sorption of arsenic are difficult because they can vary by several orders of magnitude, depending upon valence (arsenic valence is unknown for the Del Amo site) and pH conditions. The solubility of arsenic and thallium at the site is unlikely to be as high as that for benzene however, and may be much lower.

susceptible to transformations and thus are likely to be more persistent in the environment than the VOCs and SVOCs.

13.2.3 Conceptual Site Model and Exposure Pathways

The CSM for the Del Amo site is presented in Figure 60. The primary sources of COPCs are inferred to be historical chemical product releases from former aboveground storage tanks and other facilities at the former plant site. Additional sources unrelated to the former plant site have also contributed to groundwater contamination present. Impacted media, which also serve as secondary sources, include soils and groundwater. For the purposes of the CSM, NAPL is considered to be part of these media and is not considered separately. Transport mechanisms, which can also be considered secondary release mechanisms, include fugitive dust emissions, volatilization from soil, and volatilization from groundwater. While other chemical transport mechanisms exist, those identified here are limited to those with the potential to lead directly to exposures.

“Exposure route” refers to the method by which a chemical may enter the body. Applicable exposure routes include inhalation of soil particulates, inhalation of soil vapor, inhalation of groundwater vapor, ingestion of soil, and dermal contact with soil. Receptors are those organisms that are potentially exposed to the chemicals, and include human receptors, which are the primary focus of the BRA, and other biota, which are evaluated as part of ecological risk assessment. Human receptors for the former plant site are further divided into three types based on potential differences in the nature of their exposures: (1) commercial workers, which includes most of the indoor work force for current businesses at the former plant site; (2) trench workers, who would be more likely to be exposed to subsurface soil; and (3) future hypothetical residents, who would potentially be present on a nearly continuous basis. There are currently no known full time residents at the former plant site, and current zoning is restricted to commercial/industrial land use.

An exposure pathway is the complete route and mechanisms by which a chemical of concern reaches a receptor. A “complete” exposure pathway exists where there is a continuous link between the chemical source, release mechanism, transport medium, migration route, exposure medium, and potential receptor(s), indicating there is a potential for exposure. The CSM integrates all of the complete exposure pathways and shows how they are interrelated. Pathways incorporating future residents are identified as “potentially complete” in the CSM since such receptors are hypothetical.

Complete and potentially complete exposure pathways are summarized in more detail in the table below with respect to their receptors, exposure media, and exposure route (sources, release

13.0 CONTAMINANT FATE AND TRANSPORT

mechanisms, and transport mechanisms removed). This table illustrates how the various sample media data presented in this RI report apply to the exposure pathways that are evaluated in the BRA.

Receptor	Exposure Media	Exposure Route
Commercial worker	Surface soil	Incidental ingestion Dermal contact Fugitive dust Inhalation
	Shallow soil/soil gas	Incidental ingestion Dermal contact Fugitive dust and vapor inhalation Vapor inhalation in indoor air
	Deep soil/soil gas	Vapor inhalation in indoor air
	Groundwater (water table only)	Vapor inhalation in indoor air
	Indoor air	Vapor inhalation in indoor air
Hypothetical future resident	Shallow soil/soil gas	Incidental ingestion Dermal contact Fugitive dust and vapor inhalation Vapor inhalation in indoor air
	Deep soil/soil gas	Vapor inhalation in indoor air
	Groundwater (water table only)	Vapor inhalation in indoor air
Trench worker	Shallow soil/soil gas	Incidental ingestion Dermal contact Fugitive dust inhalation

Further evaluation of the exposure pathways described above is presented in the BRA. The BRA quantitatively evaluates potential chemical exposures and associated health risks through mathematical modeling of chemical migrations and concentrations at locations of potential human exposure.

14.0 SUMMARY AND CONCLUSIONS

14.1 SOIL

Evaluation and reporting of soil contaminant conditions within the former plant site were based on soil gas data for VOCs and soil data for VOCs, SVOCs/PAHs, pesticides/PCBs, metals, and cyanide. VOCs, and benzene in particular, are considered to be the contaminants of primary concern at the former plant site based on their relative prevalence, concentrations, mobility and toxicity compared to other compounds.

14.1.1 VOCs

The soil gas and soil data show that elevated VOC levels are associated with several former plant site facilities, primarily various storage tank areas and ethylbenzene/styrene production trains in the styrene plancor, and laboratory and pipeline area within the butadiene plancor. The principal VOC contaminants in these areas are benzene, and in some areas, ethylbenzene. An additional area of PCE and TCE contamination is present in the southwestern corner of the copolymer plancor at the “pits and trenches” feature. There is no known history of use of these compounds at the former plant site. However, a release of these compounds from within the former plant site area cannot be ruled out, since there is no documentation indicating the former use of the pits and trenches. There are known sources of chlorinated solvents at adjacent properties to the west of the former plant site, and maximum TCE and PCE concentrations in groundwater measured to date also occur in that area. EPA’s investigation of chlorinated solvents in the vicinity of the pits and trenches is ongoing. EPA may issue future amendments or addenda to this RI report in the event that new information becomes available.

VOC-impacted soil associated with rubber plant facilities is suspected to be present under the footprint of some current buildings. As an alternative to intrusive and disruptive subsurface sampling, indoor air monitoring for VOCs was completed at these buildings, where feasible. The purpose of the indoor air monitoring was to evaluate whether there were any immediate health risks; the data are not suitable for evaluation of actual subsurface conditions underlying the buildings. No immediate health risks were identified for the 12 buildings where indoor air sampling was completed based on the lack of VOC detections in excess of OSHA PELs or the more conservative, project-specific PEL/20 screening criteria.

14.1.2 SVOCs/PAHs

SVOCs/PAHs are generally present at lower concentrations in soil at the former plant site and are not as prevalent as VOCs. Concentrations in excess of screening criteria were sporadically detected within the three rubber plant plancors, but typically did not extend beyond a single sampling location at the targeted facilities. The area of the copolymer plancor laboratory is the

sole exception to this, where PAH exceedances were detected in each of four neighboring sample locations adjacent to the footprint of the former facility. The SVOC/PAH most commonly detected in excess of its screening criteria was benzo(a)pyrene.

Concentrations of SVOCs/PAHs in excess of screening criteria were not detected in any of the 39 deep soil samples analyzed from 23 soil borings. This is likely attributable to the relatively low mobility of SVOCs/PAHs. Twelve of the 14 screening criteria exceedances in shallow soil were from within the upper 5 feet of soil, with the remaining two being from 6 and 10 feet bgs, providing further evidence of the limited vertical migration of the SVOCs/PAHs.

14.1.3 Pesticides/PCBs

Pesticide/PCB screening criteria exceedances were limited to DDT isomers or Aroclor 1260 (a PCB) at five shallow soil sampling locations in the western portion of the former plant site. Three of the four sampling locations with DDT exceedances are in an area of exposed surface soil near the southwest corner of the former plant site. This area is directly downwind of the Montrose property, where DDT was manufactured. The remaining exceedances were near the northwest corner and southwest corners of the copolymer plant, for Aroclor 1260 and DDT, respectively.

Pesticides and PCBs are similar to SVOCs/PAHs in that they are typically relatively immobile in soil. This is supported by the available deep soil data, which indicate pesticides/PCBs were not detected at concentrations in excess of screening criteria.

14.1.4 Metals

Metals were sporadically detected at concentrations in excess of screening criteria in each of the former plant sites. Arsenic, copper, thallium, lead and manganese were detected in one or more samples at concentrations in excess of screening criteria. Arsenic was the metal most frequently detected in excess of screening criteria (nine locations), although there is no clear association with former plant site facilities.

The three elevated copper detections at the former plant site are at targeted wastewater treatment impoundment and copper solvent tank facilities and are therefore inferred to be associated with rubber plant operations. While of potential concern, these areas of elevated copper are very limited in extent. This is also true for the areas of elevated thallium at the waste water treatment impoundment and near a former styrene production area, although the use for thallium at the rubber plant, if any, is unclear. The lead and manganese exceedances are of unknown origins and are limited to single sampling locations.

The mobility of metals in soil is typically limited. This is consistent with the soil data, which show that for 17 screening criteria exceedances, 13 were at depths of five feet or less.

14.1.5 Cyanide

Cyanide was not present at detectable concentrations in any soil samples and is therefore not judged to be a contaminant of concern at the former plant site.

14.2 GROUNDWATER

Water table groundwater data are relevant to this report with respect to evaluation of exposures from upward migration of vapor and identification of potential NAPL areas and groundwater contamination source areas. Groundwater data considered in this report are limited to VOC data for the water table from the 2000 groundwater monitoring event. Investigation of groundwater conditions in the vicinity of the former plant site is continuing as part of Groundwater Remedial Design activities, and additional data and findings from these activities will be considered by EPA in preparation of the soil and NAPL ROD, as applicable.

Benzene is the VOC that has the widest distribution and is most commonly detected at elevated concentrations in the water table. The dissolved plumes for non-benzene VOCs within the former plant site area are generally found within the benzene plume. Dissolved benzene is divided between western and eastern plume areas, which are centered over the styrene plancor and the butadiene plancor laboratory area, respectively. Areas of local benzene concentration maxima are commonly near areas of known or potential LNAPL, and concentrations approach the benzene solubility limit (1,800,000 µg/l) in some areas.

While the potential for surface exposures from vapor migration cannot be ruled out, soil gas data show that VOC concentrations near the surface are commonly very low or undetectable, even in areas of known or suspected NAPL or areas where dissolved VOCs are known to be present in the water table zone at high concentrations. This is likely due to the depth to the water table (approximately 40-50 feet), which allows for significant attenuation of concentrations through dilution, diffusion, dispersion, biodegradation, and other natural processes, and also the relatively fine-grained, low permeability nature of the vadose zone soil across the former plant site, which impedes upward vapor migration. Areas where VOCs are elevated in shallow soil or soil gas are interpreted to be due to local shallow soil contamination rather than upward migration from deeper groundwater and/or NAPL sources. These areas of shallow contamination are of greater concern with respect to exposure via a vapor migration pathway, and were taken into consideration in the BRA.

14.3 NAPL

Evaluation of NAPL at the former site is based on observational findings (Sudan Red, UV-light, and jar testing) and laboratory data (hydrocarbon saturation data for soil samples, deep soil gas data and dissolved VOC data for groundwater samples). Three types of NAPL areas are identified based on these data:

- (1) Areas where NAPL is potentially present based on dissolved VOC concentrations, but has not been observed or measured;
- (2) Areas where NAPL is present, but at residual (non-mobile) saturations; and
- (3) Areas where NAPL has accumulated within a monitoring well or temporary well point.

NAPL accumulations (type 3) are known to have occurred only at the MW-20 and butadiene plancor laboratory areas (source areas #3 and #12, respectively). The MW-20 NAPL is composed almost entirely of benzene and thus is an LNAPL. The source area #12 NAPL is also an LNAPL, but is likely composed of multiple compounds, including BTEX, styrene and many others.

NAPL that is limited to residual saturations (type 2) is present in the area of the former VOC tank farm within the styrene plancor and adjacent to a former benzene feedstock pipeline (source areas #6 and #11, respectively). The source area #6 LNAPL is likely composed of benzene and ethylbenzene and the source area #11 LNAPL is entirely benzene.

Observational and hydrocarbon saturation data indicate that LNAPL may be present within both the vadose and saturated zones at the former plant site, but occurs largely at residual saturations. Vadose zone NAPL is inferred to be a remnant from the downward migration of the LNAPL after its release, and is essentially equivalent to what is more commonly referred to as soil contamination. The most prominent example of this is at the former butadiene plancor laboratory area (source area #12). NAPL within the saturated zone is typically present in a “smear zone” at each of the type 2 and type 3 NAPL areas evaluated. These smear zones are inferred to have been created by a rising water table after an LNAPL has accumulated on the water table. As the water table rises, some of the NAPL is trapped and retained in pore spaces by capillary forces.

NAPL is potentially present, but has not been observed or measured (type 1), at the following areas, as shown on Figures 57 and 58:

14.0 SUMMARY AND CONCLUSIONS

- The western styrene finishing/benzene purification unit in the styrene plancor (source area #4);
- Both ethylbenzene production units in the styrene plancor (source areas #7 and #8);
- The utility tank storage area (source area #9);
- The Waste Pit Area (source area #10);
- The pits and trenches area of the copolymer plancor (source area #2); and
- The southwest corner of the styrene plancor (not associated with a rubber plant facility).

The potential NAPL areas associated with source areas #4, #7, #8, #9, and #10 above are all attributed to past releases of benzene and/or ethylbenzene (LNAPL components) from the specified rubber plant facilities. The potential NAPL areas at source area #2 and the southwestern corner of the styrene plancor are related to high dissolved concentrations of TCE/PCE and chlorobenzene, respectively. These chlorinated compounds are DNAPL components and have no known history of use at the former plant site. There are known source areas for each of these DNAPL components to the west of the former plant site, in the immediate vicinity of the areas where they were detected.

14.4 GROUNDWATER CONTAMINATION SOURCE AREAS

Areas where past releases of contaminants are inferred to have migrated downward and are impacting groundwater are identified as groundwater contamination source areas. Twelve source areas were identified at the former plant site through the synthesis of historical documentation information and soil gas, soil, groundwater, and NAPL data, as follows:

Source Area	Plancor	Suspected Source Facility	Primary Contaminants	NAPL?
1	Copolymer	VOC storage tanks	Cyclohexane	Unlikely
2	Copolymer	Properties to west of former plant site	TCE, PCE	Potential DNAPL
3	Styrene	VOC Storage tanks	Benzene	LNAPL accumulation
4	Styrene	Styrene finishing/benzene purification unit	Benzene, cyclohexane	Potential LNAPL
5	Styrene	Styrene finishing/benzene purification unit	BTEX, styrene	Unlikely
6	Styrene	VOC tank farm	Benzene, ethylbenzene	Residual LNAPL
7	Styrene	Ethylbenzene production unit	Benzene, ethylbenzene	Potential LNAPL
8	Styrene	Ethylbenzene production unit	Benzene, ethylbenzene	Potential LNAPL
9	Styrene	Utility tanks	Benzene, toluene	Potential LNAPL
10	Styrene	Waste Pit Area	BTEX	Potential LNAPL
11	Butadiene	Benzene feedstock pipeline	Benzene	Residual LNAPL
12	Butadiene	Laboratory/pipelines	BTEX, styrene	LNAPL accumulation

14.0 SUMMARY AND CONCLUSIONS

Benzene is a primary contaminant at each of the source areas except source areas #1 and #2. Source area #2 is unique in that it is adjacent to a known source area to the west of, and unrelated to the former plant site, as previously discussed. It is included in the above table because soil gas and soil data indicate elevated concentrations of TCE are additionally present at the former plant site. Conversely, there are no soil gas or soil data to suggest that the potential chlorobenzene DNAPL area near the southwestern corner of the styrene plant is associated with any vadose zone contamination at the former plant site. The correspondence between the source area locations and dissolved VOC plumes at the former plant site provides additional evidence for the validity of the historical documentation information and the soil gas, soil, groundwater, and NAPL data by which the source areas were identified.

**DEL AMO REMEDIAL INVESTIGATION REPORT
SOIL AND NAPL OPERABLE UNIT**

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15.2 MAPS AND DRAWINGS

1951 Topographic Map
 1965 Topographic Map
 1981 Topographic Map
 USGS 7.5-Minute Quadrangle Torrance
 Shell drawing YT-5034
 Shell drawing YT-5037
 Shell drawing YT-5043-8
 Shell drawing YT-5050-5
 Shell drawing YT-5051-6
 Shell drawing YT-5051-7
 Shell drawing YT-5055-6
 Shell drawing YT-5058-9
 Shell drawing YT-5059-7
 Shell drawing YT-5066-4
 Shell drawing YT-5067-8
 Shell drawing YT-5628
 Shell drawing ZC-8512
 Shell drawing ZC-8514
 Shell drawing YT-11996-1
 Shell drawing YT-12019
 Shell drawing YT-12023

15.3 HISTORICAL AERIAL PHOTOGRAPHS

Date	Source*	Flight	Frame	Scale
08-00-27	Whittier	C-113	211,212	1" = 1500'
00-00-28	Whittier	C-300	88-90	1" = 1500'
03-07-37	Whittier	C-4424	2-4	1" = 1280'
03-06-41	Whittier	C-6972	39,40,53-55	1" = 1000'
08-30-41	Whittier	C-7347	43,44,64-66	1" = 1000'
12-01-41	Whittier	C-7558	1,2	1" = 1000'
11-05-46	Whittier	C-10810	20,21,38,39	1" = 800'
06-17-47	Whittier	C-11351	84,85	1" = 2000'
06-17-47	UCSB	C-11351	7:84,86	1" = 2000'
08-22-47	Whittier	C-11703	3:9,10	1" = 4000'
05-28-51	Whittier	C-16580	1:31	1" = 2000'
12-13-51	Whittier	C-17188	1:8,4:5	1" = 800'
12-04-52	UCSB	AXJ	7K:157,158	1" = 1667'

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Date	Source*	Flight	Frame	Scale
05-08-53	Whittier	C-19375	6:27,28	1" = 2640'
10-03-53	Whittier	C-19660	B:6,7	1" = 1000'
12-18-54	Whittier	C-21250	1:20,21	1" = 2000'
04-05-56	Whittier	C-22478	1:35,36	1" = 2600'
07-15-56	UCSB	C-22555	24:26	1" = 1200'
08-13-56	UCSB	C-22555	25:26-27	1" = 1200'
01-17-58	UCSB	C-23023	VII-LA 5:62,63	1" = 3000'
05-08-60	UCSB	C-23870	593,594,608,609	1" = 1200'
08-10-62	UCSB	PAI	175V:17,18,21,22	1" = 1500'
02-28-63	D&M ¹		1:86	1" = 315'
03-20-63	UCSB	PAI	204V:45,46	1" = 4000'
04-03-63	UCSB	PAI	205V:219,220	1" = 4000'
01-01-65	UCSB	PAI	1933 01:28,29	1" = 3000'
09-22-65	UCSB	C-25019	1533 19:359,360	1" = 2000'
10-06-67	D&M ²		4-22	1" = 600'
08-22-68	UCSB	TG-2400	2:6,7	1" = 2400'
09-23-68	UCSB	TG-2400	6:40,41	1" = 2400'
00-00-69	UCSB	LA Aerial Atlas	LB-12,18	1" = 1200'
02-08-70	D&M ²		61-7-180	1" = 600'
03-17-71	UCSB	TG-2755	3:18,19	1" = 870'
10-11-71	D&M ³		3	1" = 320'
10-03-72	D&M ¹		3-103	1" = 325'
01-20-73	UCSB	TG-7300	15:6,7	1" = 2000'
11-00-73	D&M ⁵	258	01-0193	1" = 1000'
03-28-75	D&M ⁶	92227	598,599	1" = 1368'
03-22-76	UCSB	TG-7600	4:12, 5:18,19	1" = 2000'
05-12-79	D&M ²		FCLA 10-116	1" = 300'
11-15-79	D&M ⁴	TG-3800-002	17:17	1" = 274'
08-24-80	UCSB	USDA Firescope	780:141	1" = 3333'
04-23-82	UCSB	Firescope III	7-142	1" = 2000'
08-22-89	UCSB	NAPP	1840:150	1" = 3333'

*Source Notes:

Whittier: Whittier College, Department of Geology, Fairchild Aerial Photograph Collection, Whittier, California

UCSB: University of California, Santa Barbara, Map & Imagery Laboratory, Santa Barbara, California

D&M: Dames & Moore in-house photograph collection from:

¹ Enlargement from U.S. Geological Survey, EROS Data Center, Sioux Falls, South Dakota

² Enlargement from Continental Aerial Photo Inc., Los Alamitos, California

³ Enlargement from American Aerial Surveys of Southern California, Covina, California

⁴ Enlargement from UCSB

⁵ Enlargement from U.S. Geological Survey, Earth Science Information Center, Reston, Virginia

⁶ Enlargement from Brewster Pacific Corporation, Pasadena, California