Walter B. Howard (4-6029) - Corporate Engineering, St. Louis F4EA

September 3, 1974

CORRECTIONS TO LP&EC REVIEW
REPORT #74-47 (8/28/74)
CEA 2908, Monomer Removal,
Texas City

K. M. Kettler - F3WA
R. J. Kozacka - G2WD
Russell L. Miller - F4EA
[redacted]
S&PP Location File (TEXAS CITY)

D. H. Bolliger, Project Mgr.

G 2 W C

E r r a t a

COPIES TO THOSE PRESENT

R. L. Bauer - F4WE
R. A. Bell - F2EC
D. H. Bolliger - G2WC
B. W. Eley - A2SA
J. E. Fox - 1890, Tex.City
M. E. Gibbs - W1A
W. B. Howard - F4EA
M. L. Mullins - E1SF
W. J. Raiff - W1A
W. R. Richard - T3A
J. R. Savage - B2SL
R. F. Seifert- F2EC
A. K. Shadensack - 1890, Tex.City

Thank you for your call on August 30. You had noted items needing correction in Report #74-47. My apology for the errors. I am glad to make the corrections, as follows:

1. Page 1 of Report: The completion target date is the last quarter of 1975.

2. Page 3 of Rept., item 8: The report mentions vacuum pumps in the present polymer manufacturing operation. This is erroneous. The present process is above atmospheric pressure throughout.

3. Page 4 of Report, para. 2: The first sentence is erroneous. It needs to be changed to the following: "Downstream of the two Frymas will be an evaporator."

Walter B. Howard

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bordered by an athletic field to the southwest and open fields to the northwest.
Mud Gully transects the overall site between Brio North and Dixie North as well as forming one boundary of the Dixie South site. Other areas surrounding both sites are open lands used for oil and gas production.

The Brio and DOP sites occupy 58.1 and 26.6 acres respectively. Brio North and Dixie North, both historically used for storage purposes, cover 48.8 and 19.0 acres respectively. Brio South and DOP South, both historically used for processing activities, cover 9.3 and 7.6 acres respectively.

In their current state, the most prominent structural features of the Brio and DOP sites are the tankage and processing units from former operations. The RI contains detailed maps of the site structures and reference is made to those figures for additional data. A tank farm is located on the Brio North parcel adjacent to Dixie Farm Road.

Several office type buildings and storage warehouses are located on the Brio South and DOP North and South parcels. Various components of a wastewater treatment system remain. The most prominent features of this system are the two impoundments located on the Brio North parcel.

### 2.1.2 Site History

The history of past operations summarized herein is derived from the detailed presentation in the Brio and DOP Remedial Investigations.

Aerial photographs taken from 1952 through 1956 depict the site as it existed prior to its active use as a chemical plant. Operations began at the Brio site in 1957. Photos show that diked oil stock tanks, lagoons and other structures associated with crude oil production and storage were present on site. Three sets of these structures were located on Brio North, two on Brio South, one on DOP North, and one on DOP South.

Over the years, several companies conducted operations at the facilities. Available information pertaining to past ownership and operations is summarized below:

## BRIO SITE

- 1957-1969 — In 1957, the Hard-Lowe Company started catalyst regeneration and by-product recycling operations on Brio South.

- 1969-1972 — The name of the facility was changed to the Phoenix Chemical Company plant when the Chemical Pollution Control Corporation took over operations in May 1969.

  Archem Corporation leased Brio North from Phoenix to produce chemical products from 1969-1971. Phoenix assumed operations of Archem in 1971.

- 1972-1975 — Phoenix Chemical Corp lost control of the site and its operations in 1972. The facility was purchased and operated by the Lowe Chemical Company.

- 1975-1978 — In 1975 ownership changed hands to JOC Oil Aromatics, Inc.

- 1978-1981 — The facility ownership was purchased by Friendswood Refining Corporation, a wholly owned subsidiary of the Brio Petroleum Corporation.

- 1981-1982 — There was a facility name change to Brio Refining, Inc. in 1981. Operations closed in December 1982 following the bankruptcy of Brio Refining and the Brio site has been inactive since that time.

## DOP SITE

- 1969-1978 — Intercoastal Chemical Company operated the DOP North site during this time interval.

- 1978-1986 — Dixie Oil Processors, Inc. began operation of the DOP South site in 1978. Active operations ceased in 1986.

2.1.2.1 Operations at the Brio Refining Site

From 1957 to 1969, the major industrial operations on the Brio site included regeneration of copper catalysts, recovery of petrochemicals (principally ethylbenzene) from styrene tars, and attempts to recover a variety of chemicals from vinyl chloride still bottoms. Styrene tar processing activity took place at the current Brio site. Between 1957 and 1960, several pits were constructed on Brio North and Brio South to support the styrene tar processing operations.

Reclamation of petrochemicals from phenol heavy ends, chlorinated hydrocarbons, cresylic acid, ethylene glycol, and other chemical feedstocks occurred at Brio.

Most of the storage pits on Brio North and Brio South were constructed in the period from 1964 through 1970. Due to lack of processing capacity, styrene tars were stored in four large impoundments on Brio North. Ethylbenzene, toluene, aromatic solvents, and styrene pitch were produced on site during this time period.

By 1969-70, at least fourteen pits had been constructed. The first pit closures were accomplished in 1969-70 with some pit materials left in place.

Spent caustics were stored in tanks on Brio North from 1969 to 1971. A processing operation using hydrogen sulfide, blended with spent caustic, produced cresylic acid, sodium sulfide, and sodium cresyllite. Approximately seven additional pits were closed from 1972 through 1975.

Between 1975 and 1978, the following feedstocks were utilized: styrene tar, off-spec diesel, ethylbenzene, phenol bottoms, cutter stock, caustic, crude oil, blend oil, polyethylbenzene bottoms, and crankcase oil. Products produced were: aromatic oil, fuel oil, ethylbenzene, toluene, cumene, sodium sulfide, creosote extender, and 50% caustic. As part of their operation, JOC stored styrene tar in open pits on the site. Four of these pits were closed in 1976 and 1977. Closures were reportedly conducted by mixing soil and calcined clay with the residues left in place. Soil cover was reportedly placed over the stabilized pit material. One new pit was constructed during this period.

The recycling and recovery plant at Brio was converted to a crude oil topping unit for jet fuel production in 1978.

Jet fuel, diesel fuel, residual oil, naphtha, kerosene, and fuel gas were produced by distilling petroleum feedstock (crude oil). No cracking or reforming of the feedstocks took place.

The final on site pit was closed in 1979-80. Jet fuel was produced intermittently throughout 1982. Operations were completely closed down in December 1982. The Brio site has been inactive since that time.

2.1.2.2 Operations at the Dixie Oil Processors Site

Copper recovery and hydrocarbon washing operations were carried out at DOP North from 1969 to 1978. The copper recovery operation may have used a series of surface impoundments to store cuprous wastewater prior to copper recovery, and to treat wastewater prior to discharge. A total of six impoundments were used. Wastewaters from the hydrocarbon washing operations were discharged into one of the impoundments. The impoundments were decommissioned and closed during the period.

Dixie Oil Processors began operations on DOP South in 1978. The DOP South site was used primarily for regeneration of cuprous chloride catalyst; hydrocarbon washing to produce ethylbenzene, toluene, aromatic solvents, styrene pitch, and for oil recovery; and blending of chemical plant and refinery wastes. Dixie Oil Processors used residues from local chemical plants and refineries (principally phenolic tank bottom tars and glycol cutter stock). These waste feedstocks were blended and distilled to produce various petroleum products, including fuel oil, creosote extender, and a molybdenum concentrate catalyst. A reduced level of operation is ongoing today.

Although no disposal of material in pits was known to be practiced on DOP South, an area of tarry material was found in 1984. Approximately 6,000 cubic yards of this material were removed from two areas and disposed of off site.

### 2.1.3 History of Site Investigations Prior to the RI

Several site investigations were conducted during the plant's operation and after abandonment in 1982. They are described in detail in the RI and are listed below:

- Vinyl Chloride Monomer Air Sampling (TACB, May 1976)
- Initial Site Investigation (USEPA, December 1983)
- Soil Boring and Sampling Program (NUS for Harris County Flood Control District, May 1984)
- Ambient Air Sampling and Analysis (TACB, 1984-1985)

## 2.2 SITE CHARACTERIZATION

The site characterization identifies and quantifies the chemical constituents detected at the site. A primary objective of this section is to focus the remaining sections of the EA document on the chemical constituents of concern that are present. To compile this section, all monitoring reports and chemical analytical data available in the RI and SRI were reviewed.

This section contains information on the identity, quantity and form of chemical constituents present at the sites and the concentrations of the constituents in the various environmental media.

A description of the chemical analytical data base with regard to its completeness, quality and validity is provided. Potential transport of the constituents through the environmental media is summarized. Finally, the occurrence, distribution and concentrations are defined for each constituent identified.

### 2.2.1 Scope of Work for RI and SRI

The RI consisted of a two-phase sampling and analysis program to characterize the site. The purpose of the initial RI field investigation (Phase I) was to determine the location, quantity and characteristics of materials at the site and to develop preliminary information regarding constituent mobility. In Phase I, 48 pit borings were completed and 21 soil boring grab samples were collected and analyzed to characterize pit contents. The bottom of some pits

was not established. Consequently, a second phase of the program was implemented to gather additional information.

The purpose of the Phase II field investigation was to define the extent of constituent migration. Data collection activities focused on evaluating potential environmental impacts. Twenty borings were completed into subsoil beneath the pits requiring better bottom definition. Borings were advanced two feet below the previously logged bottoms. The RI sampling activity produced samples of residuals in the pits, soil adjacent to and below the pits, shallow ground water (Numerous Sand Channel Zone), deeper ground water (Fifty-Foot Sand), wastewater treatment system water and sludge, Mud Gully sediments and stream samples, site surface water runoff, and on site ambient air (See Figure 2-3).

The Supplemental Remedial Investigation (SRI) was designed to collect additional site characterization data. For complete details of this effort, see the approved sampling and analysis plan (Woodward Clyde Consultants, 1987a). The scope of work of the SRI is summarized as follows:

> Shallow trenches were excavated to collect on site surface and subsurface soils. Additional trenches and borings were used to collect residue and soils samples to characterize the vertical distribution of constituents. Additional ground water samples were taken to supplement and verify ground water quality. Samples of on site and off site soils and sediments were collected and analyzed to furnish data for the EA and FS. Surface water was again sampled.

A total of 138 volatiles, 54 base/neutrals and 10 priority pollutant analyses derived from this sampling program were used to characterize the site for the EA. A listing of the chemical constituents detected on site and used in the EA to characterize the Brio and DOP sites is presented in Table 2-1.

### 2.2.2 Summary of Chemical Analytical Data and Statistics

The data base presented in the RI and SRI has been categorized by environmental media (e.g., soils, sediments, ground water, etc.), and evaluated statistically. The resulting summary provided in Appendix A serves to organize the data used to address the occurrence, distribution, prevalence, and development of source terms for the EA.

TABLE 2-1
SUMMARY OF ORGANIC AND INORGANIC COMPOUND
FOUND AT THE BRIO REFINING/DIXIE OIL PROCESSORS SITE
(Page 1 of 4)

| DETECTED CONSTITUENT | CHEMICAL CLASS | MEDIA | MAX. OBSERVED CONC. (PPM) |
|---|---|---|---|
| Acenapthylene | Base/Neutral | Mud Gully Sediment | 30 |
| | | Surface Soil | 0.1 |
| Antimony | Inorganic | Pit | 600 |
| Benzene | Volatile | Pits | 242 |
| | | Numerous Sand Channel Zone (NSCZ) Wells | 257 |
| Benzo(A)Anthracene | PNA | Wastewater Treatment System (WTTS) | 16 |
| | | Mud Gully Sediment | 8 |
| Benzo(A)Pyrene | PNA | WWTS | 3 |
| | | Mud Gully Sediment | 3 |
| Benzo(B)Fluoranthene | PNA | WWTS | 11 |
| | | Mud Gully Sediment | 6 |
| Benzo(G,H,I)Perylene | PNA | WTTS | 4 |
| Benzo(K)Fluoranthene | PNA | WTTS | 11 |
| | | Mud Gully Sediment | 24 |
| Bis(2-Chloroethyl)Ether | Base/Neutral | Pits | 3,040 |
| | | NSCZ Wells | 3,170 |
| | | Runoff to Mud Gully | 45 |
| | | Fifty-Foot Sand Well | 0.01 |
| Bis(2-Ethylhexyl) Phthalate | Base/Neutral | NSCZ Well | 293 |
| | | Surface Soil | 11 |
| Carbon Tetrachloride | Volatile | NSCZ Well | 171 |
| Chlorobenzene | Volatile | NSCZ Wells | 3650 |
| | | Pits | 1150 |
| | | Surface Soil | 1.12 |
| Chloroform | Volatile | NSCZ Wells | 3,580 |
| | | Fifty-Foot Sand Well | 0.1 |
| | | Runoff to Mud Gully | 0.004 |
| Chromium$^{+3}$ | Inorganic | Pits | 860 |
| | | WWTS | 94 |
| | | Mud Gully Sediment | 39 |

TABLE 2-1 (Continued)
SUMMARY OF ORGANIC AND INORGANIC COMPOUND
FOUND AT THE BRIO REFINING/DIXIE OIL PROCESSORS SITE
(Page 2 of 4)

| DETECTED CONSTITUENTS | CHEMICAL CLASS | MEDIA | MAX. OBSERVED CONC. (PPM) |
|---|---|---|---|
| Chrysene | PNA | WWTS | 85 |
| | | Mud Gully Sediment | 171 |
| Copper | Inorganic | Pits | 98,900 |
| | | WWTS | 1763 |
| | | Mud Gully Sediment | 10,215 |
| | | Runoff to Mud Gully | 14 |
| | | NSCZ Wells | 110 |
| Dibenzo(A,H)Anthracene | PNA | WWTS | 5 |
| | | Mud Gully Sediment | 11 |
| Di-n-Butyl Phthalate | Base/Neutral | Runnoff to Mud Gully | 10 |
| 1,2-Dichlorobenzene | Base/Neutral | NSCZ Wells | 182 |
| 1,3-Dichlorobenzene | Base/Neutral | NSCZ Wells | 742 |
| 1,4-Dichlorobenzene | Base/Neutral | NSCZ Wells | 235 |
| 1,1-Dichloroethane | Volatile | NSCZ Wells | 3,380 |
| | | Run-Off | 0.001 |
| 1,2-Dichloroethane | Volatile | Pits | 245,000 |
| | | Subsoils | 515 |
| | | NSCZ Wells | 39,000 |
| | | Runoff to Mud Gully | 26 |
| | | Fifty-Foot Sand Wells | 0.6 |
| 1,1-Dichloroethylene | Volatile | NSCZ Wells | 140 |
| | | Fifty-Foot Sand Wells | 0.2 |
| | | Pits | 1570 |
| | | Surface Soil | 25.9 |
| | | Runoff to Mud Gully | 0.02 |
| 1,2 Dichloroethylene (Trans) | Volatile | NSCZ Wells | 8,820 |
| (Dichloromethane) Methylene Chloride | Volatile | Pits | 909 |
| | | Subsoils | 58 |
| | | Surface Soils | 55 |
| | | NSCZ Wells | 110 |
| | | Runoff to Mud Gully | 11 |
| | | Fifty-Food Sand Wells | 0.01 |

TABLE 2-1 (Continued)
SUMMARY OF ORGANIC AND INORGANIC COMPOUNDS
FOUND AT THE BRIO/DIXIE OIL PROCESSORS SITE
(Page 3 of 4)

| DETECTED CONSTITUENT | CHEMICAL CLASS | MEDIA | MAX. OBSERVED CONC. (PPM) |
|---|---|---|---|
| Ethylbenzene | Volatile | Pits | 3370 |
| | | NSCZ Wells | 4750 |
| | | Surface Soil | 146 |
| Fluoranthene | Base/Neutral | Pits | 988 |
| | | NSCZ Wells | 148 |
| | | WWTS | 206 |
| | | Mud Gully Sediment | 159 |
| | | Surface Soil | 124 |
| Fluorene | Base/Neutral | NSCZ Wells | 428 |
| | | WWTS | 35 |
| | | Mud Gully Sediment | 7.5 |
| | | Pits | 50.4 |
| | | Surface Soil | 19.8 |
| Hexachlorobenzene | Volatile | Pit BB | 5.0 |
| | | Pit EE | 674 |
| Hexachlorobutadiene | Base/Neutral | NSCZ Wells | 44 |
| Hexachloroethane | Base/Neutral | NSCZ Wells | 27 |
| Indeno(1,2,3-CD) Pyrene | PNA | WWTS | 2 |
| | | Mud Gully Sediment | 3 |
| Lead | Inorganic | Pits | 1,320 |
| | | NSCZ Wells | 0.1 |
| Napthalene | Base/Neutral | NSCZ Wells | 1850 |
| | | WWTS | 27 |
| | | Pits | 110 |
| | | Surface Soil | 61.5 |
| Nickel | Inorganic | Pits | 179 |
| Phenanthrene | Base/Neutral | Pits | 6670 |
| | | NSCZ Wells | 8880 |
| | | WWTS | 25 |
| | | Mud Gully Sediments | 3 |
| | | Surface Soil | 1340 |
| Selenium | Inorganic | Pits | 51 |
| 1,1,2,2-Tetrachloroethane | Volatile | NSCZ Wells | 777 |
| Tetrachloroethylene | Volatile | NSCZ Wells | 1,580 |
| | | Surface Soil | 0.1 |

TABLE 2-1 (Continued)
SUMMARY OF DETECTED ORGANIC AND INORGANIC COMPOUNDS
FOUND AT THE BRIO/DIXIE OIL PROCESSORS SITE
(Page 4 of 4)

| DETECTED CONSTITUENT | CHEMICAL CLASS | MEDIA | MAX. OBSERVED CONC. (PPM) |
|---|---|---|---|
| Toluene | Volatile | Surface Soil | 110 |
| | | NSCZ Wells | 437 |
| | | Pits | 69.9 |
| 1,1,1-Trichloroethane | Volatile | NSCZ Well | 166 |
| 1,1,2-Trichloroethane | Volatile | Pits | 166,000 |
| | | Sub Pits | 918 |
| | | NSCZ Wells | 48,700 |
| | | Runoff to Mud Gully | 0.1 |
| | | Surface Soil | 6.4 |
| | | Fifty-Foot Sand Well | 0.6 |
| Trichloroethylene | Volatile | Surface Soil | 2.1 |
| | | NSCZ Wells | 2,760 |
| | | Fifty-Foot Sand Well | 0.03 |
| Vinyl Chloride | Volatile | Pits | 22,700 |
| | | NSCZ Wells | 8,400 |
| | | Fifty-Foot Sand Well | 0.3 |
| | | Surface Soil | 6.8 |
| | | Runoff to Mud Gully | 0.1 |

The following data summary tables are contained in Appendix A.

| TABLE NO. | DESCRIPTION |
|---|---|
| A-1 | Pit Residuals (RI) |
| A-2 | Pit Subsoils (RI) |
| A-3 | Mud Gully Sediments (RI) |
| A-4 | Pit Q Drainageway and Mud Gully Sediments (SRI) |
| A-5 | Brio Shallow and Deep Ground Water (RI) |
| A-6 | Non-Aqueous Phase Liquid Fraction of Ground Water (RI) |
| A-7 | DOP Shallow and Deep Ground Water (RI) |
| A-8 | NSCZ Ground Water Statistical Analysis (RI) |
| A-9 | NSCZ Ground Water (SRI) |
| A-10 | Surface Water (SRI) |

The following summary statistics tables for volatile organic (VO) and base-neutral-acid (BNA) constituents are also contained in Appendix A.

| TABLE NO. | DESCRIPTION |
|---|---|
| A-11 | Off Site Residential Surface Soils (0-1 ft.) (VO) |
| A-12 | Off Site Residential Surface Soils (0-1 ft.) (BNA) |
| A-13 | Off Site Residential Surface Soils (9-10 ft.) (VO) |
| A-14 | Off Site Residential Surface Soils (9-10 ft.) (BNA) |
| A-15 | DOP South Surface Soil Locations (VO) |
| A-16 | DOP South Surface Soil Locations (BNA) |
| A-17 | Brio Shallow Trench 50 (VO) |
| A-18 | Brio Shallow Trench 51 (VO) |
| A-19 | Brio Shallow Trench 51 (BNA) |
| A-20 | Brio Trenches 50 and 51 (15 ft.) (VO) |
| A-21 | Mud Gully Bank (VO) |
| A-22 | Mud Gully Surface Water (BNA) |

### 2.2.3 Quality and Validity of the Chemical Data

The data used for the performance of this EA were obtained directly from the data base as presented in the RI and SRI reports. No data validation or review of laboratory or field QA/QC procedures and reports was specifically done as part of the EA process. No additional data were collected specifically for the EA.

### 2.2.4 Occurrence and Distribution of Constituents

A major part of the site characterization is a baseline presentation of the occurrence and distribution of constituents at the site. This presentation is accomplished by using the available chemical analytical data to characterize concentration levels and distribution of individual chemicals found in ambient air, pit residues, on site and off site surface soils and sediments, ground water and surface water. Consequently, the pits and other site materials are portrayed by single sets of statistical parameters.

#### 2.2.4.1 Ambient Air

During ambient air monitoring volatile organic compounds were detected in very low concentrations. Benzene, toluene, xylene, styrene, 1,2-dichloroethane, 1,1,1-trichloroethane, and vinyl chloride were detected. Most of the compounds were present at concentrations below 1 part per billion (ppb), a level considered to constitute background. See the detailed description in the RI report (REI, 1987a).

#### 2.2.4.2 Surface Soils and Sediments

Surface soil samples were collected both on site and off site during the SRI. Appendix A, Tables A-11 thru A-16, contain the summary statistics of the analytical results.

Shallow off site residential soil analyses at a 0-1 foot depth are clean, i.e., the results are predominately below analytical detection limits. Only µg/kg concentrations of two compounds, methylene chloride and bis(2-ethylhexyl) phthalate (DEHP), were found.

Off site residential soil samples collected at a depth of 9 to 10 feet are also relatively clean. The following compounds were detected at concentrations of 10 to 300 µg/kg: ethylbenzene, methylene chloride, DEHP, fluorene, naphthalene and phenanthrene. None of these compounds were particularly prevalent, as they were detected in only two samples out of eleven analyzed. Methylene chloride was prevalent (nine of eleven samples with a maximum concentration of 73 µg/kg).

Analytical results for on site soil samples at DOP South detected one volatile compound, (methylene chloride) in two of five samples at a maximum concentration of 10 µg/kg. Di-n-butyl phthalate was detected in one of seven samples analyzed, at a concentration of 66 µg/kg. The remaining compounds detected are classified as non-carcinogenic PNAs. None were prevalent; PNAs were found in only one of six samples.

Runoff to Mud Gully contained very low (µg/kg) concentrations of the volatile organic constituents identified in pit materials. Mud Gully sediments did not contain these volatiles, but did contain total copper concentrations up to 2.0 mg/l and total PNA concentrations up to 0.4 mg/l. Heavy metals, i.e., nickel, selenium, antimony, and lead, were found in the DOP pits. Hexachlorobenzene was found in DOP Pit BB and EE.

Trench samples collected near Pit Q provide additional information on constituents in soils. Samples collected during the SRI south of Pit Q (shallow trench 50) indicate the presence of nine volatile compounds at low µg/kg concentrations. The compounds have a low prevalence since they were detected in only one or two samples of seven analyzed. These data indicate the presence of 1,1,2-trichloroethane in two of seven samples at concentrations of 8.7-23.9 µg/kg. This compound was the Pit Q constituent detected at the highest concentration, and was also detected in Pit Q subsoils. 1,1,2-trichloroethane was also present in the trench data.

Trench samples were collected east of Pit Q. The volatile constituents present are the same as those detected south of Pit Q, but at slightly higher concentrations. Ethylbenzene is present at higher concentrations (35.3-10,400 µg/kg) and at a greater prevalence (nine of ten samples). Toluene was detected in six of ten samples at a maximum concentration of 678 µg/kg. Base/neutral analyses indicate the presence of fifteen compounds. The most prevalent constituents, and those present in the highest concentrations, are the non-carcinogenic PNAs. However, benzo(a)anthracene and benzo(b)-fluoranthene (both known and suspected carcinogens) are present. Benzo(a)-anthracene was reported in two of six samples at a range of 67-603 µg/kg, and benzo(b)fluoranthene was present in three of six samples at a range of 84 to 2,500 µg/kg.

The constituents and concentrations present in shallow trench samples do appear to indicate some migration of Pit Q constituents horizontally. However, at depth (15 feet) in some trench locations (i.e., south and east of Pit Q), no significant migration was detected.

Sanitary sewage sludge which was imported in the past and is contained in numerous piles on the northwest section of Brio was sampled. EP toxicity metals analyses were negative for the sludge. Five volatile priority pollutant compounds were detected in the following concentrations: methylene chloride, 39.1 - 55.1 µg/kg; tetrachloroethylene, ND - 58.3 µg/kg; toluene, 35.1 - 110 µg/kg; 1,1,1-trichlorethane, BMDL - 49.1 µg/kg; and trichlorethylene, ND - 36.3 µg/kg. As expected, the sample collected near the bottom of these piles exhibited concentrations higher than the top samples which are more exposed to air, thereby promoting more volitilization. Five compounds were detected in the bottom sample while only two were detected at the surface.

2.2.4.3 Ground Water

Analytical results from sampling of the Numerous Sand Channel Zone (NSCZ) indicate the presence of chlorinated organic compounds: 1,1,2-trichloroethane; 1,2-dichloroethane; vinyl chloride; methylene chloride; and bis(2-chloroethyl)ether. The spatial distribution was variable, ranging from near or less than analytical detection levels over much of the site to several hundred mg/l in some areas (e.g., near Pits B, J and Q). Off site monitor wells installed in the Southbend subdivision showed concentrations of voltatiles high as 19,000 mg/l near the site boundary and no chlorinated organics in the NSCZ a few hundred feet beyond the site boundary.

Eleven wells were completed in the Fifty-Foot Sand at the Brio/DOP site and were sampled for priority pollutants. Eight of the wells did not show any detectable levels of priority pollutants.

Trace levels of organic constituents were detected in samples from the BMW-3B and BMW-4B Fifty-Foot Sand wells during the RI field work. A series of samples (time series) were collected over several days while the wells were being pumped to confirm the presence or absence of organic constituents. The

results of this sampling program demonstrated that volatile organic constituents are not present in the Fifty-Foot Sand at these locations. Only one sample from the BMW-4B well, collected in the middle of the time series, showed any trace levels. All subsequent samples from this well showed non-detectable levels. The sampling showed that the initially detected organic constituents in these wells were probably artificially introduced during drilling of the wells.

Low concentrations of organic volatile constituents (1 to 2 mg/l) were detected in the BMW-13B well during the initial portion of the SRI field study. Time series sampling of the well was initiated in April 1987 to determine whether the constituents were introduced artificially during the well construction.

During the time series sampling of BMW-13B, the concentrations of all the constituents showed reductions of at least an order of magnitude during the first few samplings and then leveled off at about 60 to 80 µg/l for 1,2-dichloroethane and 20 µg/l or less for the other constituents. The results of the time series sampling at the BMW-13B well indicate that a high proportion of the initially detected organic constituent levels are attributable to the well drilling and completion process. The constituent concentration levels measured in the later samples of the time series represent the water quality in the Fifty-Foot Sand in this locality. Consequently, it appears that organic constituents in the Fifty-Foot Sand are localized, occurring in the vicinity of the BMW-13B well. Organic constituents were not detectable at any of the other Fifty-Foot Sand well locations.

The contention that organic constituents in the Fifty Foot Sand are localized is based on consideration of organic migration rates and dilution/dispersion effects in the Middle Clay Unit and the Fifty-Foot Sand. Conservative calculations of migration rates indicate that maximum concentration levels in the Fifty-Foot Sand in the vicinity of pit J would have been expected at the time of pit closure around 1970. Since that time, it is likely that upward hydraulic gradients have prevailed in this area as are presently observed. These upward gradients are sufficient to counteract density flow of heavier-than-water DNAPL particularly as this was observed to be very viscous

liquid. No additional organic contributions to the Fifty-Foot Sand at this location are believed to be occurring at the present time and a gradual reduction of concentration levels due to natural flushing is anticipated (Appendix A of Summary Report).

Based on calculated groundwater flow velocities to the south-southeast ranging from 4 to 58 feet per year it may be estimated that the extent of groundwater impact in the Fifty-Foot Sand is between 80 and 1100 feet to the south of pit J if no dispersion/dilution effects are considered. These latter effects are probably very significant so that, more realistically, the extent of affected groundwater is unlikely to be more than 300-400 feet south of pit J. The closest observation well in the Fifty Foot Sand in this direction is BMW-3B approximately 800 feet to the south-southeast of pit J. This well has no detectable organics which would be expected from the above discussion.

#### 2.2.4.4 Surface Water

Extensive sampling and testing of surface waters, both stream and runoff, was conducted during in the RI and SRI. The sampling program was designed to test the qualitative presumption of impact on Mud Gully since the gully is in the direction of surface water drainage from the Brio/DOP site.

Data collected during the RI indicates minimal (µg/l) concentrations of volatile organics and PNAs present in surface water runoff from the site to Mud Gully. During the SRI, surface water samples were collected in Mud Gully at Pit B and in the Pit Q drainway. No volatile constituents were detected in the Pit Q drainway. All volatile constituents detected in Mud Gully at Pit B are at concentrations less than 1 mg/l. The analytical results are summarized in Table A-10.

## 2.3 SUMMARY

The first section of Chapter 2, Site History and Characterization, described the site in terms of geographical location, physical structures and operational history. Site investigations prior to the RI are identified. The types of chemicals processed at the site, the manner in which they were handled, and where they were placed is discussed. The data base used for the EA is described in detail and the chemical analyses are summarized.

The last section characterizes the site, identifying and quantifying the chemical constituents present and their distribution in the environmental media (Table 2-1). The identification, occurrence, and distribution of constituents of concern provides the basis for appraisal of the existing site conditions.

Chapter 3, Environmental Fate and Transport Characteristics, describes the potential mobility of the identified constituents in the various environmental media to a location where exposure may take place.

# 3.0 ENVIRONMENTAL FATE AND TRANSPORT

This chapter describes the behavior of the identified constituents in the various environmental media and explains the major factors which influence occurrence and distribution patterns presented in the previous chapter. The Environmental Fate and Transport section assists the process of selecting indicator chemicals in the following chapter, and provides background information necessary for evaluation of the remedial alternatives in the FS.

The objectives of this section are to:

- Group the constituents into categories with similar migration characteristics;
- List pertinent transport parameters based on the physical and chemical nature of the constituents; and
- Couple transport parameter information with relevant site-specific features that affect transport through the on site air, soils and water in order to identify the exposure potential associated with each class of constituents.

The major classes of constituents associated with the pit residuals, pit subsoils, surface soils and sediments, surface water, and ground water are the volatile halogenated organic compounds, such as 1,1,2-trichloroethane, 1,2-dichloroethane, vinyl chloride monomer; base/neutral extractables that include bis(2-chloroethyl)ether and polynuclear aromatics (PNAs), commonly referred to as polycylic aromatic hydrocarbons, such as phenanthrene and fluoranthene; and the inorganic metals, chromium, lead and copper. Table 3-1 contains a list of physical and chemical parameters that serve to characterize the most likely environmental fate of the constituents present in the various on site environmental media.

TABLE 3-1
PHYSICAL, CHEMICAL, AND ENVIRONMENTAL FATE PROPERTIES OF BRIO/DCP CONSTITUENTS
(Page 1 of 3)

| CLASS | CONSTITUENT | WATER (20-30°C) SOLUBILITY (MG/L) | VAPOR (20-30°C) PRESSURE (MM HG) | HENRY'S LAW CONSTANT | $K_{OC}$ ML/G | MOL. WT. | LOG $K_{OW}$ | FISH BCF[4] (L/KG) | HALF-LIFE IN AIR (DAYS) | HALF-LIFE IN SURF. WATER (DAYS) | BOILING POINT (°C) | SPECIFIC GRAVITY | FLASH POINT (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASE/NEUTRAL | ACENAPTHYLENE | 3.93 | .029 | .00145 | 2300 | 152 | 3.70 | - | 5.5 | 0.125 | 265-275 | 0.8988 | - |
| INORGANIC | ANTIMONY | INSOL | 1.00 | NA | - | 122 | - | 1.0 | 4.8 | PERSISTENT | 1380 | 6.684 | - |
| VOLATILE | BENZENE[1] | 1750 | 95.2 | .00559 | 83 | 78 | 2.12 | 5.2 | 6.0 | 1.0-6.0 | 80.1 | 0.8765 | -11 |
| PNA | BENZO(A)ANTHRACENE | .0057 | $2.2X10^{-8}$ | $1.16X10^{-6}$ | $1.38X10^{6}$ | 228 | 5.6 | - | 5.0 | 0.1-5.0 | 435 | - | - |
| PNA | BENZO(A)PYRENE | .0012 | $9.6X10^{-9}$ | $1.55X10^{-6}$ | $5.5X10^{5}$ | 252 | 6.06 | - | 1.0-6.0 | 0.4 | 310 | - | - |
| PNA | BENZO(B)FLUORANTHENE | .014 | $9.0X10^{-7}$ | $1.19X10^{-5}$ | $5.5X10^{5}$ | 252 | 6.06 | - | 5.5 | 1.0-2.0 | - | - | - |
| PNA | BENZO(G,H,I)PERYLENE | .0007 | $1.03X10^{-10}$ | $5.34X10^{-8}$ | $1.6X10^{6}$ | 276 | 6.51 | - | - | - | - | - | - |
| PNA | BENZO(K)FLUORANTHENE | .0043 | $5.10X10^{-7}$ | $3.94X10^{-5}$ | $5.5X10^{5}$ | 252 | 6.06 | - | - | - | - | - | - |
| BASE/NEUTRAL | BIS(2-CHLOROETHYL)ETHER | 10,200 | .710 | $1.31X10^{-5}$ | 15.9 | 143 | 1.50 | 6.9 | - | - | 178 | 1.2199 | 55 |
| BASE/NEUTRAL | BIS(2 ETHYLHEXYL) PHTHALATE | .285 | 1.3 | - | - | 391 | 8.38 | - | - | - | 385 | 0.9861 | 218 |
| VOLATILE | CARBON TETRACHLORIDE | 757 | 90.0 | .02411 | 110 | 154 | 2.64 | 19 | 8030.0 | 0.3-300.0 | 76.7 | 1.59 | NONE |
| VOLATILE | CHLOROBENZENE | 466 | 11.7 | .00572 | 550 | 113 | 2.84 | 10 | 5.5 | 0.3 | 131 | 1.11 | 28 |
| VOLATILE | CHLOROFORM | 8200 | 150 | .00287 | 31 | 119 | 1.97 | 3.79 | 80.0 | 0.3-30.0 | 61.26 | 1.49815 | NONE |
| INORGANIC | CHROMIUM[2] | - | 0 | NA | - | 52 | - | 16 | 4.8 | 3.0 | - | 1.77 | - |
| PNA | CHRYSENE | .0018 | $6.3X10^{-9}$ | $1.05X10^{-6}$ | $2.0X10^{5}$ | 228 | 5.61 | 200 | 5.5 | 0.2 | 448 | 1.274 | - |
| INORGANIC | COPPER | - | 0 | - | - | 64 | - | 200 | - | - | 2567 | 8.92 | - |
| PNA | DIBENZO(A,H)ANTHRACENE | .0005 | $1.0X10^{-10}$ | $7.33X10^{-8}$ | $3.3X10^{6}$ | 278 | 6.50 | - | 5.5 | .0200-2.00 | - | - | - |
| BASE/NEUTRAL | DI-N-BUTYL PHTHALATE | 13.8 | $1.0X10^{-5}$ | $2.83X10^{-7}$ | $1.7X10^{3}$ | 278 | 5.60 | - | - | - | 340 | 1.048 | 157 |
| BASE/NEUTRAL | 1,2-DICHLOROBENZENE | 100 | 1.00 | .00183 | 1700 | 147 | 3.60 | 56 | 26 | 1.5-8.5 | 180-183 | 1.307 | 66 |
| BASE/NEUTRAL | 1,3-DICHLOROBENZENE | 123 | 2.28 | .00359 | 1700 | 147 | 3.60 | 56 | - | - | 173 | 1.288 | - |

[1] BENZENE FOUND ONLY IN NON-AQUEOUS PHASE ORGANIC LIQUID (NAPL)
[2] CHROMIUM INDICATED TO BE TRIVALENT IN DATA TESTED 11-13-85
[3] PROBABLE LABORATORY CONTAMINANT
[4] BCF = BIOCONCENTRATION FACTOR

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TABLE 5-1
PHYSICAL, CHEMICAL, AND ENVIRONMENTAL FATE PROPERTIES OF BRIO/DOP CONSTITUENTS
(Page 2 of 3)

| CLASS | CONSTITUENT | WATER (20-40°C) SOLUBILITY (MG/L) | VAPOR (20-40°C) PRESSURE (MM HG) | HENRY'S LAW CONSTANT | $K_{OC}$ MG/G | $MPC_{HH}$ MG/L | LOG $K_{OW}$ | BCF[1] (L/KG) | HALF-LIFE IN AIR (DAYS) | HALF-LIFE IN SURF. WATER (DAYS) | BOILING POINT (°C) | SPECIFIC GRAVITY | FLASH POINT (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BASE/NEUTRAL | 1,4-DICHLOROBENZENE | 79 | 1.18 | .00289 | 1700 | 147 | 3.60 | 56 | 23 | 1.5-8.5 | 175.4 | 1.4581 | 66 |
| VOLATILE | 1,1-DICHLOROETHANE | 5500 | 182 | .00431 | 30 | 99 | 1.79 | - | 45 | 1-9 | 57.3 | 1.174 | -17 |
| VOLATILE | 1,2-DICHLOROETHANE | 8520 | 64 | $9.78 \times 10^{-4}$ | 14 | 99 | 1.48 | 1.2 | 56-127 | 0.17 | 83.5 | 1.2554 | 15 |
| VOLATILE | 1,1-DICHLOROETHYLENE | 2250 | 600 | 0.34 | 65 | 97 | 1.84 | 5.6 | 2.0 | 1.0-6.0 | 37 | 1.218 | -18 |
| VOLATILE | 1,2-TRANS-DICHLOROETHYLENE | 6,300 | 324 | .00656 | 50 | 97 | 0.48 | 1.6 | 2.1 | 1-6 | 47.8 | 1.257 | 2 |
| VOLATILE | METHYLENE CHLORIDE[3] (DICHLOROMETHANE) | 20000 | 362 | .00203 | 8.8 | 85 | 1.30 | 5 | 33.2 | 1.20-9.80 | 39.8 | 1.326 | - |
| VOLATILE | ETHYLBENZENE | 152 | 7 | .06643 | 1100 | 106 | 3.15 | 37.5 | 1.46 | 1.5-7.5 | 136 | 0.867 | 17 |
| BASE/NEUTRAL | FLUORANTHENE | .206 | $5.0 \times 10^{-6}$ | $6.46 \times 10^{-6}$ | 38000 | 202 | 4.90 | 1150 | 5.5 | 1.0-2.0 | 375 | 1.252 | - |
| BASE/NEUTRAL | FLUORENE | 1.89 | $7.1 \times 10^{-4}$ | $6.42 \times 10^{-5}$ | 7300 | 166 | 4.20 | 1300 | - | - | 295 | - | - |
| VOLATILE | HEXACHLOROBENZENE | .006 | $1.09 \times 10^{-5}$ | $6.81 \times 10^{-4}$ | 3900 | 285 | 5.25 | 8,690 | 80.0 | 0.5-300.0 | 326 | 1.57 | 117 |
| BASE/NEUTRAL | HEXACHLOROBUTADIENE | 0.15 | 2.0 | 4.57 | 29000 | 261 | 4.76 | 2.8 | 0.2 | 29-2500 | 212 | 1.675 | - |
| BASE/NEUTRAL | HEXACHLOROETHANE | 50 | 0.4 | .00249 | 20000 | 237 | 4.6 | 87 | 7900 | 1.10-9.50 | 186.8 | 2.091 | - |
| PNA | INDENO(1,2,3-CD) PYRENE | .00053 | $1.0 \times 10^{-10}$ | $6.86 \times 10^{-8}$ | $1.6 \times 10^{6}$ | 276 | 6.50 | - | 3.50 | .0208-2.08 | 536 | - | - |
| INORGANIC | LEAD | - | 0 | NA | - | 207 | - | 49 | 4.80 | PERSISTENT | 1740 | 11.34 | - |
| BASE/NEUTRAL | NAPTHALENE | 30 | - | - | - | 128 | - | - | - | 0.5 | 218 | 1.152 | 79 |
| INORGANIC | NICKEL | - | 0 | NA | - | 59 | - | 47 | - | - | 2730 | 8.90 | - |
| BASE/NEUTRAL | PHENANTHRENE | 1.0 | $6.8 \times 10^{-4}$ | $1.58 \times 10^{-4}$ | 14000 | 178 | 4.46 | 2630 | - | 0.58-2.0 | 340 | 1.025 | - |
| INORGANIC | SELENIUM | - | 0 | NA | - | 79 | - | 18 | - | - | 690 | 4.26-4.81 | - |
| VOLATILE | 1,1,2,2-TETRACHLORO-ETHANE | 2900 | 5.00 | $3.81 \times 10^{-4}$ | 178 | 168 | - | 42 | - | 1.40 | 146.4 | 1.600 | - |
| VOLATILE | TETRACHLOROETHYLENE | 150 | 17.80 | .0259 | 364 | 166 | 2.6 | 31 | 47 | 1-30 | 121.2 | 1.6311 | NONE |
| VOLATILE | TOLUENE | 535 | 28.1 | .00637 | 300 | 92 | 2.75 | 10.7 | 1.3 | 0.17 | 111 | 0.8660 | 4 |
| VOLATILE | 1,1,1-TRICHLOROETHANE | 1500 | 123 | .0144 | 152 | 133 | 2.5 | 5.6 | 805-1752 | 0.14-7.0 | 74.1 | 1.3376 | NONE |
| VOLATILE | 1,1,2-TRICHLOROETHANE | 4500 | 30.0 | .00117 | 56 | 133 | 2.47 | 5 | 24 | 1.90 | 114 | 1.4416 | - |

[1] BCF = BIOCONCENTRATION FACTOR
(MG/KG/MG/L)(0.12)

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TABLE 3-1
PHYSICAL, CHEMICAL, AND ENVIRONMENTAL FATE PROPERTIES OF BRIO/DOP CONSTITUENTS
(Page 1 of 3)

| CLASS | CONSTITUENT | WATER (20-30°C) SOLUBILITY (MG/L) | VAPOR (20-30°C) PRESSURE (MM HG) | HENRY'S LAW CONSTANT | $K_{OC}$ ML/G | MW, WT. | LOG $K_{OW}$ | FISH BCF[1] (L/KG) | HALF-LIFE IN AIR (DAYS) | HALF-LIFE IN SURF. WATER (DAYS) | BOILING POINT (°C) | SPECIFIC GRAVITY | FLASH POINT (°C) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| VOLATILE | TRICHLOROETHYLENE | 1100 | 57.9 | .009) | 126 | 131 | 2.38 | 10.6 | 3.7 | 1.0-90.0 | 86.7 | 1.4649 | 32 |
| VOLATILE | VINYL CHLORIDE | 2670 | 2660 | .0819 | 57 | 63 | 1.38 | 1.17 | 1.20 | 1.0-5.0 | -13.9 | 0.9195 | -8 |

REFERENCES:

Clements Assoc, (1985)
Sax (1979)
EPA (October 1986)
Versar (Jan, 14, 1986)
Verschueren (1983)

[1]BCF = BIOCONCENTRATION FACTOR

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## 3.1 PHYSICAL AND CHEMICAL CHARACTERISTICS OF IDENTIFIED COMPOUNDS

A brief description of transport and mobility related parameters typically used in assessing the behaviour of constituents in the environment is presented in Table 3-1. The parameters are briefly described below:

- Water Solubility is the maximum concentration of a chemical that dissolves in pure water at a specific temperature and pH. It is a critical property affecting environmental fate and transport. Chemicals with high water solubility will tend to be transported from soil to ground water and surface water rather than remaining in soil or volatilizing.

- Vapor Pressure is a relative measure of the volatility of a chemical in its pure state and is an important determinant of the rate of volatilization. Values for this parameter, in units of mm Hg, are given for a temperature range of 20 to 30°C. Constituents with high vapor pressure are more likely to migrate from soils and ground water and be transported in air.

- Henry's Law Constant is another parameter important in evaluating air exposure pathways. Values for Henry's Law Constant (H) were calculated using the following equation and the values recorded for solubility, vapor pressure and molecular weight:

$$H(atm\text{-}m^3/mole) = \frac{\text{Vapor Pressure (atm) X Mole Weight (g/mole)}}{\text{Water Solubility } (g/m^3)}$$

- Organic Carbon Partition Coefficient ($K_{oc}$) is a measure of the tendency for organics to be adsorbed by soil and sediment and is expressed as:

$$K_{oc} = \frac{\text{mg chemical adsorbed/kg organic carbon}}{\text{mg chemical dissolved/liter of solution}}$$

  The $K_{oc}$ is chemical specific and is largely independent of soil properties. The higher the $K_{oc}$ valve the more adsorbable the compound.

- Octanol-Water Partition Coefficient ($K_{ow}$) is a measure of how a chemical is distributed at equilibrium between octanol and water. $K_{ow}$ is an important parameter and is used often in the assessment of environmental fate and transport for organic chemicals. High $K_{ow}$ values are generally indicative of a chemical's ability to accumulate in fatty tissues and therefore biomagnify in the food chain. The $K_{ow}$ also helps to determine a chemical's movement from an organic matrix to water and soil. Additionally, $K_{ow}$ is a key variable used in the estimation of other properties.

- Bioconcentration Factor as used in this document is a measure of the tendency for a chemical in water to accumulate in fish tissue. The equilibrium concentration of a chemical in fish can be estimated by multiplying the concentration of the chemical in surface water by the fish bioconcentration factor for that chemical. This parameter is therefore an important determinant for human intakes via the aquatic food ingestion route.

- Chemical Half-Lives are used as measures of persistence, or how long a chemical will remain in various environmental media. Table 3-1 presents values for overall half-lives, which are the results of all removal processes (e.g., phase transfer, chemical transformation and biological transformation) acting together rather than a single removal mechanism.

## 3.2 MIGRATION CHARACTERISTICS OF THE PRINCIPAL CONSTITUENTS

Each of the listed classes of chemical constituents detected at the site, i.e., PNAs, phthalate esters, volatile halogenated organics, semi-volatile halogenated organics, and inorganic heavy metals, will behave differently in the environment. A short description of their behavior is given below:

- Migration of PNAs - Generally, PNAs are highly immobile in soils due to their low water solubility (thus non leachable). Their high partition coefficient ($K_{OW}$) and high soil adsorption coefficients ($K_{OC}$) combined with their resistance to oxidation or hydrolysis are indicative of their persistence in the soil environment. They are usually found bound to particulates and soils, unless there are high enough concentrations of organic solvents present in the soils to allow migration of organic contaminants by nonaqueous phase liquid (NAPL) flow conditions (Villaume, 1985).

  PNAs will not volatilize, as indicated by the low vapor pressure, and therefore are not of concern in the air pathway (except as particulate emissions). They are not subject to hydrolysis or oxidation but may be biodegraded by selective soil microorganisms. Usually, PNAs will not be transported in the environment except by physical means such as sediment in surface runoff during storm events.

  Migration of PNAs is expected to be extremely limited.

- Migration of Phthalate Esters - The phthalate esters have a relatively low water solubility, i.e., 1.3 milligrams per liter (mg/l) for bis(2-ethylhexyl) phthalate and should be relatively immobile in subsurface soils. They will not be readily transported to surface water due to low water solubility, and will not readily volatilize as indicated by the very low vapor pressure. Consequently, phthalates will typically be carried along during physical transport of surface soils during storm events.

- Migration of Inorganic Heavy Metals - Chromium, copper and lead are normally distributed between the liquid and the solid phase in soils. In the pore water of the soil, they may exist as free ions or as organic/inorganic complexes, where their mobility depends on the avaflability of organic carbon for absorption and inorganic liquids for ion exchange and their respective solubilities.

  In the solid phase, metals may be incorporated into crystalline minerals of the parent rock material (dependent on origin of the sand particles) and secondary clay minerals, or precipitate as insoluble organic or inorganic complexes. They may also be loosely or tightly sorbed onto exchange sites.

  Their transport via the air pathway is a concern only to the extent that soil particles to which the metals may be sorbed are subject to wind-driven erosion.

  Transformation from aqueous and solid phases depends on the chemical environment of the soil. For most metals, the possibility of leaching to ground water is limited. Most metals are precipitated from the soil leaching medium. However, pH of 2-3 is required before extraction of a significant amount of metals occur (Brown, 1980).

- Migration of Volatile Halogenated Organics - The volatile organic constituents detected at the Brio site are generally mobile in the soil environment due to high vapor pressures indicative of volatility, and high water solubility. Their high octanol/water coefficient and low soil adsorption coefficient are indicators of a limited capacity to adsorb to soil particles. These characteristics may explain their presence in some of the surface water samples. Concentrations would be rapidly attenuated in a moving stream, however, where aeration takes place due to turbulent flow.

## 3.3 SUMMARY

In the preceding chapter, the constituents of potential concern have been identified and their concentrations and distribution patterns described. Based on the identification, the constituents were delineated into classes in terms of their environmental behavior. This chapter presented chemical properties and provided a general evaluation of the constituents' potential for mobility and transport in the environment.

In the following chapter, the constituents found at the site are evaluated as to which may pose actual or potential risks to the public health and the environment, should sufficient exposure occur. From this evaluation a group of indicator chemicals can be defined that represent the risks associated with potential exposure to site constituents. The hazard component of risk will be defined in site-specific terms to provide the information needed to support subsequent exposure assessments.

4.0

# 4.0 HAZARD IDENTIFICATION

The site has been described by identifying the constituents, their occurrence, and their distribution patterns in the environmental media. Behavior of the constituents was characterized generally by their chemical and physical nature to predict potential for migration to an off site location where exposure could take place. This section will provide the toxicity characterization needed to assess the potential risks to public health and the environment posed by this site.

Due to the large number of chemicals found in the on site residuals (Table 2-1), it is necessary to select a smaller group of indicator chemicals that adequately represents the potential hazards and probability of exposure. An initial screening of the constituents of concern and a selection protocol is delineated that result in a list of indicator chemicals.

The following section catalogs and characterizes the intrinsic hazards to human health and the environment posed by the detected chemical constituents in light of site-specific circumstances. Initially, chemical data were compiled. Information on the chemicals detected, their prevalence, distribution, detected concentrations at the site, and their toxicity was developed. From these considerations, the chemical analytical data for the Brio/DOP site were assessed and indicator chemicals were selected.

## 4.1 SELECTION OF THE INDICATOR CHEMICALS

To perform the EA, it is necessary to address the hazards associated with the chemical constituents found in the various environmental media. The effectiveness of the evaluation is not generally enhanced by considering all of the contaminants that were detected. To do so tends to mask certain critical concerns and makes characterization of risk unnecessarily complicated. Therefore, selection of indicator chemicals of concern by chemical, or chemical class, supplies adequate data for the evaluation and provides a representative evaluation of the present situation. This approach presumes that remediation

involving indicator chemicals will also result in the remediation of less prevalent and lower concentration constituents that were not selected as indicator chemicals.

The principal organic and inorganic compounds detected at the Brio/DOP site are found in 21 backfilled pits and several wastewater handling units. These compounds are listed in Table 2-1. The pits contain residual styrene tar, vinyl chloride tars, chlorinated solvents, copper catalysts, and fuel oil.

The following criteria were utilized to select the indicator chemicals from Table 2-1 for the health risk assessment and environmental impact analysis:

- If there were significant potential health consequences (based on environmental mobility, toxicological potential, or level of exposure) associated with an individual constituent in site-specific circumstances, the constituent was considered to be significant and included in the risk assessment.
- The most prevalent constituents found in all of the environmental media (ambient air, subsoils, groundwater, surface water, and pit residuals) were selected.
- If within a class of related chemicals, the overall effects of exposure to any of these constituents could be adequately described and evaluated based on a single chemical within the class, then that indicator contaminant was chosen.

Tables 4-1, 4-2, 4-3, and 4-4 summarize the results of a quantitative screening of potential indicator chemicals. Constituents were ranked in the referenced tables by environmental media (i.e., pits, soils, sludges, Mud Gully sediments, ground water) based on toxicity, prevalence, concentration, and mobility. Evaluating the results across the media and coupling this with a qualitative evaluation, described below for all compounds listed in Table 2-1, produced the final list of indicator chemicals (Section 4.2). The screening rationale for each chemical is presented below.

TABLE 4-1
PHYSICAL/CHEMICAL/TOXICOLOGICAL
RANKING OF POTENTIAL INDICATOR CHEMICALS
FOR PIT MATERIALS


| CHEMICAL | CARCINOGENICITY RANKING[1] (INGESTION) | (INHALATION) | PREVALENCE | CONCENTRATION RANK | MAX.,mg/kg | MOBILITY: VAPOR PRESSURE RANK | mmHg | WATER SOLUBILITY RANK | mg/l | $K_{oc}$[2] RANK | (ml/ |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **PIT RESIDUALS SHOWING HIGHEST CONSTITUENT LEVELS** | | | | | | | | | | | |
| | | | PIT B | | | | | | | | |
| 1,2-DICHLOROETHANE | 1 | 1 | 2/2 | 1 | 245,000 | 1 | 64 | 2 | 8,520 | 2 | 1 |
| 1,1,2-TRICHLOROETHANE | 2 | - | 2/2 | 2 | 166,000 | 2 | 30 | 3 | 4,500 | 1 | 1 |
| BIS(2-CHLOROETHYL)ETHER | 3 | - | 1/1 | 3 | 3,040 | 3 | 0.71 | 1 | 10,200 | 3 | 13. |
| CHROMIUM | - | 2 | 2/2 | 4 | 77 | - | - | - | - | - | |
| | | | PIT J | | | | | | | | |
| 1,2-DICHLOROETHANE | 2 | 1 | 2/2 | 1 | 179,000 | 2 | 64 | 2 | 8,520 | 3 | |
| 1,1,2-TRICHLOROETHANE | 3 | - | 2/2 | 2 | 89,100 | 3 | 30 | 3 | 4,500 | 2 | 1 |
| VINYL CHLORIDE | 1 | 2 | 1/2 | 3 | 22,700 | 1 | 2,660 | 4 | 2,670 | 1 | |
| BIS(2-CHLOROETHYL)ETHER | 4 | - | 1/1 | 4 | 1,410 | 4 | 0.71 | 1 | 10,200 | 4 | 13. |
| | | | PIT Q | | | | | | | | |
| 1,2-DICHLOROETHANE | 1 | 1 | 2/3 | 1 | 26,100 | 2 | 64 | 3 | 8,520 | 2 | |
| 1,1,2-TRICHLOROETHANE | 3 | - | 3/3 | 2 | 8,140 | 3 | 30 | 4 | 4,500 | 1 | 1 |
| BIS(2-CHLOROETHYL)ETHER | 2 | - | 1/1 | 3 | 1,810 | 4 | 0.71 | 2 | 10,200 | 3 | 13. |
| METHYLENE CHLORIDE | 4 | 2 | 3/3 | 4 | 909 | 1 | 362 | 1 | 20,000 | 4 | 8. |

(1)Ranking determined by multiplying unit cancer risk (ingestion or inhalation) X maximum concentration.
(2)$K_{oc}$ indicates the tendency of an organic chemical to be absorbed. Low $K_{oc}$ values will tend to be leachable from soil mobile in ground water.

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TABLE 4-1
PHYSICAL/CHEMICAL/TOXICOLOGICAL
RANKING OF POTENTIAL INDICATOR CHEMICALS
FOR PIT MATERIALS
PAGE 2 OF 2

| CHEMICAL | CARCINOGENICITY RANKING[1] (INGESTION) | (INHALATION) | TOXICITY[3] | PREVALENCE IN PITS | CONCENTRATION RANK | CONCENTRATION MAX.,mg/Kg | MOBILITY: VAPOR PRESSURE RANK | VAPOR PRESSURE mmHg | WATER SOLUBILITY RANK | WATER SOLUBILITY mg/l | $K_{oc}$[2] RANK | $K_{oc}$[2] (ml/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PIT RESIDUALS SHOWING LOWER CONSTITUENT LEVELS | | | | | | | | | | | | |
| 1,1,2-TRICHLOROETHANE | 4 | - | +2 | A,E,K,P,F | 3 | 932 | 3 | 30.0 | 3 | 4,500 | 4 | 56 |
| ETHYLBENZENE | - | - | Repro. Tox | E,F,H,I,K,R | 8 | 558 | 5 | 7 | 5 | 152 | 2 | 1,100 |
| CHROMIUM | - | 1 | +4 | L,O,R,AA,BB,CC,DD, EE,FF | 5 | 860 | | - | | - | | - |
| 1,2-DICHLOROETHANE | 3 | 2 | +1 | E,F,K,R,H | 4 | 930 | 4 | 64 | 2 | 8,520 | 4 | 14 |
| METHYLENE CHLORIDE | 5 | 3 | -1 | I | 9 | 256 | 2 | 362 | 1 | 20,000 | 5 | 8.8 |
| VINYL CHLORIDE | 2 | 4 | 0 | K | 11 | 68 | 1 | 2,660 | 4 | 2,670 | 5 | 57 |
| NICKEL | - | - | +2 | BB,CC | 10 | 179 | | - | | - | | - |
| SELENIUM | - | - | Toxic | CC | 12 | 51 | | - | | - | | - |
| ANTIMONY | - | - | Toxic | CC | 7 | 600 | | - | | - | | - |
| LEAD | - | - | Toxic | AA,CC,DD,EE,FF | 2 | 1,520 | | - | | - | | - |
| HEXACHLOROBENZENE | 1 | - | +3 | BB,EE | 6 | 674 | 6 | $1 \times 10^{-5}$ | 6 | 0.006 | 1 | 3,900 |

(1) Ranking determined by multiplying unit cancer risk (ingestion or inhalation) X maximum concentration.
(2) (2)$K_{oc}$ indicates the tendency of an organic chemical to be absorbed. Low $K_{oc}$ values will tend to be leachable from soil and mobile in ground water.
(3) For carcinogens the CAG $\log_{10}$ potency index is given. On this scale, a chemical with an index of +3 is about a thousand times more potent than a chemical with an index of zero.

BRO/ENDA$$$4Tr(2)

TABLE 4-2
PHYSICAL/CHEMICAL/TOXICOLOGICAL
RANKING OF POTENTIAL INDICATOR CHEMICALS
SUBSOIL AND WASTEWATER TREATMENT SYSTEM SLUDGES

| CHEMICAL | CARCINOGENICITY RANKING(1) (ING.) | (INHAL.) | PREVALENCE NO. OF PITS | MOBILITY: CONCENTRATION RANK | MAX.mg/kg | VAPOR PRESSURE RANK | mmHg | WATER SOLUBILITY RANK | mg/l | $K_{oc}$(2) RANK | (ml/g) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **SUBSOIL** | | | | | | | | | | | |
| 1,1,2-TRICHLOROETHANE | 1 | - | 8 | 1 | 918 | 3 | 30 | 3 | 4,500 | 2 | 56 |
| 1,2-DICHLOROETHANE | 2 | 1 | 7 | 2 | 515 | 2 | 64 | 2 | 8,520 | 3 | 14 |
| METHYLENE CHLORIDE | 3 | 2 | 3 | 3 | 58 | 1 | 362 | 1 | 20,000 | 4 | 8.8 |
| 1,1,2,2-TETRACHLOROETHANE | 4 | - | 1 | 4 | 1 | 4 | 5 | 4 | 2,900 | 1 | 118 |
| **WASTEWATER TREATMENT SYSTEM SLUDGES** | | | | | | | | | | | |
| | | | NO. OF SAMPLES | | | | | | | | |
| CHROMIUM | - | 1 | 6 | 1 | 94 | | - | | - | | - |
| CHRYSENE | 1 | 2 | 1 | 2 | 85 | 4 | $6.3X10^{-9}$ | 4 | 0.0018 | 6 | 200,000 |
| BENZO(A)ANTHRACENE | 2 | 3 | 5 | 3 | 16 | 3 | $2.2X10^{-8}$ | 2 | 0.0057 | 4 | 1,380,000 |
| BENZO(B)FLUORANTHENE | 3 | 4 | 5 | 4 | 11 | 2 | $5X10^{-7}$ | 1 | 0.014 | 5 | 550,000 |
| BENZO(K)FLUORANTHENE | 4 | 5 | 8 | 4 | 11 | 1 | $5.1X10^{-7}$ | 3 | 0.0043 | 5 | 550,000 |
| BENZO(G,H,I)PERYLENE | 6 | 7 | 2 | 5 | 4 | 6 | $1.03X10^{-10}$ | 6 | 0.0007 | 3 | 1,600,000 |
| INDENO(1,2,3-CD)PYRENE | 8 | 9 | 5 | 8 | 2 | 7 | $10^{-10}$ | 7 | 0.00053 | 3 | 1,600,000 |
| DIBENZO(A,H)ANTHRACENE | 5 | 6 | 2 | 6 | 5 | 7 | $10^{-10}$ | 8 | 0.0005 | 2 | 3,300,000 |
| BENZO(A)PYRENE | 7 | 8 | 4 | 7 | 3 | 5 | $5.6X10^{-9}$ | 5 | 0.0012 | 1 | 5,500,000 |

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(1)Ranking determined by multiplying unit cancer risk (ingestion or inhalation) X maximum concentration.
(2)$K_{oc}$ indicates the tendency of an organic chemical to be absorbed. Low $K_{oc}$ values will tend to be leachable from soil and mobile in ground water.

BRO/ENDASSS4Tr(6)

TABLE 4-3
PHYSICAL/CHEMICAL/TOXICOLOGICAL
RANKING OF POTENTIAL INDICATOR CHEMICALS

RUNOFF TO MUD GULLY AND
MUD GULLY SEDIMENT

| CHEMICAL | CARCINOGENICITY RANKING[1] (INGESTION) | PREVALENCE NO. LOCATIONS | MOBILITY: CONCENTRATION RANK | CONCENTRATION MAX. mg/kg | MOBILITY: VAPOR PRESSURE RANK | VAPOR PRESSURE mmHg | MOBILITY: WATER SOLUBILITY RANK | WATER SOLUBILITY mg/l | $K_{oc}$[2] RANK | $K_{oc}$[2] (ml/g) |
|---|---|---|---|---|---|---|---|---|---|---|
| **RUNOFF TO MUD GULLY** | | | | | | | | | | |
| 1,1,2-TRICHLOROETHANE | 2 | 2 | 1 | 72 ppb | 3 | 30 | 4 | 4,500 | 2 | 56 |
| BIS(2-CHLOROETHYL)ETHER | 1 | 1 | 2 | 45 ppb | 4 | 0.71 | 2 | 10,200 | 4 | 13.9 |
| 1,2-DICHLOROETHANE | 3 | 1 | 3 | 26 ppb | 2 | 64 | 3 | 8,520 | 3 | 14 |
| METHYLENE CHLORIDE | 4 | 2 | 4 | 11 ppb | 1 | 362 | 1 | 20,000 | 5 | 8.8 |
| DI-N-BUTYL PHTHALATE | - | 1 | 5 | 10 ppb | 5 | $10^{-5}$ | 5 | 13 | 1 | 170,000 |
| **MUD GULLY SEDIMENT** | | | | | | | | | | |
| CHRYSENE | 1 | 5 | 1 | 171 | 4 | $6.3X10^{-9}$ | 4 | 0.0018 | 7 | 200,000 |
| CHROMIUM | - | 8 | 2 | 39 | | - | | - | | - |
| BENZO(K)FLUORANTHENE | 2 | 2 | 3 | 24 | 1 | $5.1X10^{-7}$ | 3 | 0.0043 | 5 | 550,000 |
| DIBENZO(A,H)ANTHRACENE | 3 | 4 | 4 | 11 | 6 | $10^{-10}$ | 7 | 0.0005 | 2 | 3,300,000 |
| BENZO(A)ANTHRACENE | 4 | 3 | 5 | 8 | 3 | $2.2X10^{-8}$ | 2 | 0.0057 | 4 | 1,380,000 |
| BENZO(B)FLUORANTHENE | 5 | 4 | 6 | 6 | 2 | $5X10^{-7}$ | 1 | 0.014 | 6 | 550,000 |
| BENZO(A)PYRENE | 6 | 2 | 7 | 3 | 5 | $5.6X10^{-9}$ | 5 | 0.0012 | 1 | 5,500,000 |
| INDENO(1,2,3-CD)PYRENE | 7 | 1 | 8 | 3 | 6 | $10^{-10}$ | 6 | 0.00053 | 3 | 1,600,000 |

---

(1)Ranking determined by multipyling unit cancer risk (ingestion) X maximum concentration.
(2)$K_{oc}$ indicates the tendency of an organic chemical to be absorbed. Low $K_{oc}$ values will tend to be leachable from soil ar mobile in ground water.

BRO/ENDASSS4Tr(5)

TABLE 6-4
PHYSICAL/CHEMICAL/TOXICOLOGICAL
RANKING OF POTENTIAL INDICATOR CHEMICALS

(CONSTITUENTS PRESENT IN THE NSCZ)

| CHEMICAL | PREVALENCE RANK | PREVALENCE NO. WELLS | CONCENTRATION[1] RANK | CONCENTRATION[1] MAX. mg/kg | MOBILITY VAPOR PRESSURE RANK | MOBILITY VAPOR PRESSURE mmHg | MOBILITY WATER SOLUBILITY RANK | MOBILITY WATER SOLUBILITY mg/l | MOBILITY $K_{oc}$[2] RANK | MOBILITY $K_{oc}$[2] (ml/g) | UNIT CANCER RISK (Ingestion) | CANCER RISK FACTOR[3] VIA INGESTION | RANK |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1,1,2-TRICHLOROETHANE | 2 | 9 | 1 | 48,700 | 11 | 30 | 6 | 4,500 | 12 | 56 | $1.64\times10^{-6}$ | 79.9 | 5 |
| 1,2-DICHLOROETHANE | 1 | 10 | 2 | 39,000 | 9 | 64 | 5 | 8,520 | 15 | 14 | $2.6\times10^{-6}$ | 101 | 3 |
| VINYL CHLORIDE | 3 | 8 | 3 | 8,400 | 1 | 2,660 | 8 | 2,670 | 11 | 57 | $6.6\times10^{-5}$ | 554 | 1 |
| 1,1-DICHLOROETHYLENE | 4 | 5 | 4 | 8,820 | 2 | 600 | 9 | | 10 | | $1.7\times10^{-5}$ | 150 | 2 |
| CHLOROFORM | 6 | 2 | 5 | 5,580 | 5 | 150 | 4 | 8,200 | 13 | 31 | $2.5\times10^{-6}$ | 8.2 | 7 |
| 1,1-DICHLOROETHANE | 4 | 5 | 6 | 5,380 | 4 | 182 | 5 | 5,500 | 14 | 30 | - | - | - |
| BIS(2-CHLORO ETHYL)ETHER | 5 | 3 | 7 | 5,170 | 17 | 0.710 | 2 | 10,200 | 16 | 13.9 | $3.1\times10^{-5}$ | 98.0 | 4 |
| TRICHLOROETHYLENE | 6 | 2 | 8 | 2,760 | 10 | 57.9 | 12 | 1,100 | 7 | 12.6 | $3.1\times10^{-7}$ | 8.6 | 6 |
| TETRACHLOROETHYLENE | 6 | 2 | 9 | 1,580 | 12 | 17.8 | 14 | 150 | 4 | 364 | $1.46\times10^{-6}$ | 2.3 | 8 |
| 1,1,2,2-TETRACHLOROETHANE | 7 | 1 | 10 | 777 | 13 | 5 | 7 | 2,900 | 5 | 168 | $5.7\times10^{-6}$ | 4.4 | 7 |
| 1,3-DICHLOROBENZENE | 6 | 2 | 11 | 742 | 14 | 2.28 | 15 | 123 | 3 | 1,700 | - | - | - |
| BIS(2-ETHYLHEXYL)PTHALATE | 7 | 1 | 12 | 293 | -- | -- | 18 | 0.285 | -- | | $1.99\times10^{-8}$ | 0.00511 | 13 |
| BENZENE | 6 | 2 | 13 | 257 | 7 | 95.2 | 10 | 1,750 | 9 | 83 | $1.49\times10^{-6}$ | 0.38 | 10 |
| 1,4-DICHLOROBENZENE | 6 | 2 | 14 | 235 | 16 | 1.18 | 16 | 79 | 3 | 1,700 | - | - | - |
| 1,2-DICHLOROBENZENE | 6 | 2 | 15 | 182 | 9 | 64 | 3 | 8,520 | 15 | 14 | - | - | - |
| CARBON TETRACHLORIDE | 7 | 1 | 16 | 171 | 8 | 90 | 13 | 757 | 8 | 110 | $3.71\times10^{-6}$ | 0.634 | 9 |
| 1,1,1-TRICHLOROETHANE | 7 | 1 | 17 | 166 | 6 | 123 | 11 | 1,500 | 6 | 152 | - | - | - |
| METHYLENE CHLORIDE | 5 | 3 | 18 | 110 | 2 | 362 | 1 | 20,000 | 17 | 8.8 | $2.14\times10^{-7}$ | 0.0235 | 11 |
| HEXACHLOROBUTADIENE | 7 | 1 | 19 | 44 | 15 | 2 | 19 | 0.19 | 1 | 29,000 | $2.21\times10^{-7}$ | 0.0097 | 12 |
| HEXACHLOROETHANE | 7 | 1 | 20 | 27 | 18 | 0.4 | 17 | 50 | 2 | 20,000 | $4.0\times10^{-8}$ | 0.00108 | 13 |

(1) Many of the reported maximums are for non aqueous phase organic liquids, i.e. free product, detected in wells 13A and 18A during the RI but not re-confirmed in the SRI.
(2) $K_{oc}$ indicates the tendency of an organic chemical to be absorbed. Low $K_{oc}$ values will tend to be leachable from soil and mobile in ground water.
(3) Unit cancer risk (ingestion) x (maximum) concentration.

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### 4.1.1 Inorganic Compounds

Inorganic compounds such as antimony, chromium, copper, nickel, lead, and selenium were detected on site. These compounds were not included as indicators for the following reasons:

Antimony - Rationale for Elimination: It is not prevalent (a single detection in one pit). No evidence was recorded of its being leached to ground water. Although the metal has innate toxicity, it is not a known mutagen or teratogen. It is not present in on site monitoring wells. Its aquatic toxicity is low.

Chromium - Rationale for Elimination: It was detected in pit materials, wastewater treatment system sludges, and sediments. However, analytical testing indicates that chromium present is not in a leachable form. No chromium was detected in ground water analyses. Chromium is indicated as a carcinogen only via the inhalation route of exposure (based on industrial fumes in an occupational setting) and in the hexavalent form. The chromium detected at Brio/DOP is indicated to be in the non carcinogenic trivalent form.

Copper - Rationale for Elimination: Copper was detected in pit materials, Mud Gully sediments and NSCZ groundwater. Analyses indicate that the copper is not in the leachable form. Copper was found in concentrations of 18.1 mg/l in monitoring well BMW-9A on the Brio site, and 110 mg/l in monitoring well DMW-24 on the Dixie site. Out of 28 analyses, these are the only two concentrations above 0.5 mg/l.

Although the metal was prevalent it is not included as an indicator chemical principally because it is only toxic to humans in high concentrations (for copper salts, the lethal dose is several ounces).

Typically, a risk assessment would assume a uniform distribution of copper throughout the NSCZ at the highest anomalous concentration. This would overstate the risks by 3 to 5 orders of magnitude. The influence of these copper concentrations in the NSCZ on concentrations in Mud Gully may be estimated on the basis of calculated NSCZ groundwater discharge to Mud Gully

and dilution effects of normal flow in Mud Gully. The maximum flow of groundwater from the DOP site towards Mud Gully is calculated to range from 6.6 to 102 gallons per year per square foot of cross-sectional flow (Summary Report). Maximum copper concentrations of 110 ppm have been observed in samples from the DMW-24A well. Copper concentrations in other DOP monitoring wells suggest that the maximum width of the NSCZ groundwater plume containing copper concentrations similar to DMW-24A levels is less than 450 feet wide. Assuming an average thickness for the NSCZ of 20 feet and contributions from the DOP North site along a 450 foot reach of Mud Gully yields a discharge to Mud Gully averaging 0.93 gpm. Copper contained in this groundwater discharge will be diluted by the flow in Mud Gully. Average flows and minimum flows in Mud Gully are estimated at 1216 and 679 gpm respectively (See Section 6.3.3).

If the discharge contained the maximum observed copper concentration of 110 ppm this would result in Mud Gully concentrations ranging from 0.08 to 0.15 ppm. On this basis, the copper concentration in the groundwater at the DOP site does not pose a threat to the aquatic environment of Mud Gully. Furthermore, the total copper concentration in Mud Gully downstream of DOP North during the RI dry weather sampling was <0.03 mg/l demonstrating the lack of impact due to the discharge of copper-containing groundwater.

Nickel - Rationale for Elimination: Nickel was present in only two pits. No nickel was detected in ground water samples or Mud Gully sediments. Nickel is a nutrient and has a low acute toxicity to mammals, and its evidence of carcinogenecity is equivocal.

Selenium - Rationale for Elimination: Selenium was detected in only one pit and at a relatively low concentration (51 mg/kg). There is no indication that the compound is leaching to ground water. There is no evidence that selenium is a carcinogen in humans. Selenium can produce toxic effects. However, the single detection of this low concentration is not of public health significance via human oral ingestion or bioccumulation by plants or animals.

Lead - Rationale for Elimination: Lead was detected only in pit materials. The lead present does not appear to be in the leachable form and no lead was detected in ground water. Lead has intrinsic toxicity and is a significant chemical from a public health perspective. It is unlikely that lead contained in DOP pits will present adverse health effects. The concentrations present are generally low (with a single isolated value of 1,320 mg/kg) and the opportunity for transport via fugitive dust emission of toxicologically significant concentrations is remote (because of their confinement in the pits).

4.1.2 Carcinogenic PNAs

The detected PNAs carcinogenic included as indicator chemicals are: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)-fluoranthene, dibenzo(a,h)anthracene and indeno(1,2,3-cd)pyrene.

Carcinogenic PNAs were found in the Mud Gully sediments at relatively low levels (3 to 24 mg/kg) during the RI and in the shallow trench near Pit Q (<1 to 25 mg/kg) during the SRI. Even though they were found in low concentrations at off site locations, are relatively inaccessible to the public; and exhibit extremely low mobility in the soil/sediment, as indicated by low water solubility and high soil adsorption coefficients, they are included in the indicator chemical list.

4.1.3 Non-carcinogenic PNAs

The prevalence of these compounds requires that, as a class, they be considered as compounds of concern. Phenanthrene, acenaphthylene, and naphthalene are the most prevalent non-carcinogenic PNAs on site. Other non-carcinogens found in the sub-soils and in on site surface soils include: fluoranthene, fluorene, anthracene, pyrene, and chrysene.

The non-carcinogenic PNAs are considered as a class of compounds; that is, a specific PNA is not selected as an indicator chemical. For purposes of the risk assessment and establishing appropriate clean-up levels, the total concentration of all non-carcinogenic PNAs detected is used as an exposure source term.

The relatively non-toxic nature of this class of compounds results in a sparse amount of available chronic toxicity data. Appropriate data for acenapthene, acenaphthylene, fluoranthene, and naphthylene were available and form the basis of the risk assessment. The toxicity of the specific PNAs is assumed to be representative of PNAs as a class of chemicals.

### 4.1.4 Volatile Organic Compounds

#### 4.1.4.1 Monocyclic Aromatic Hydrocarbons

The monocyclic aromatic hydrocarbons have been screened as reported below.

Benzene - Rationale for Elimination: Benzene was found at an elevated concentration (257 mg/l) only in the NAPL detected during Phase I of the RI. This value was unconfirmed in SRI sampling. In fact, the SRI sampling indicated low prevalence and low concentrations of benzene (less than 15 µg/l). In wells where benzene was detected at elevated concentrations (e.g. 778 µg/l) other constituents (selected as indicator chemicals) were also detected. Benzene is a known human carcinogen; however it is concluded that the other carcinogens included as indicator chemicals will adequately assess the risks of benzene.

Toluene - Rationale for Elimination: Like benzene, toluene was detected in NAPL samples. Subsequent sampling detected a low prevalence and concentration. The presence of toluene appears to be localized. Whereas benzene is a known human carcinogen, there is no evidence that toluene is carcinogenic or mutagenic in animals or humans.

Ethylbenzene - Rationale for Elimination: There is no evidence to indicate that ethylbenzene is a carcinogen. Because the compound was detected at relatively low concentrations in ground water samples, and because its occurrence in wells coincides with the presence of carcinogenic volatile compounds chosen as indicator chemicals, ethylbenzene not selected as an indicator compound.

4.1.4.2 Halogenated Aromatic Hydrocarbons

Chlorobenzene - Rationale for Elimination: Chlorobenzene was not included in the indicator chemical list although it was found in 8 of 33 samples during the SRI. Chlorobenzene is not considered to be a carcinogen and it has relatively low human and aquatic chronic and acute toxicity.

Hexachlorobenzene - Rationale for Elimination: Hexachlorobenzene was found in two samples from two pits and one pit surface soil. The compound was not detected in the ground water samples. Although hexachlorobenzene is an animal carcinogen, it was not included as an indicator chemical due to low prevalence. The presence of the constituent appears to be isolated to Brio Pit F and DOP pits BB and EE. The risks associated with the occurence of hexachlorobenzene at the DOP site are evaluated in Appendix I.

Dichlorobenzenes - Rationale for Elimination: The dichlorobenzenes detected (1,2-dichlorobenzene, 1,3-dichlorobenzene, and 1,4-dichlorobenzene) were not included as indicators due to their relatively low prevalence and low toxicity. The dichlorobenzenes are not thought to be carcinogens.

4.1.4.3 Halogenated Aliphatic Hydrocarbons

1,1,2-trichloroethane, 1-2-dichloroethane, and vinyl chloride were the most prevalent compounds found in all of the environmental media. These constituents also have the greatest associated carcinogenicity. Consequently, they were included in the list of indicator chemicals.

Methylene chloride (a potential carcinogen) is included as an indicator chemical since it is widely distributed (present in pits, soils, ground water, and surface water). There is some question regarding the prevalence of this constituent as it is often associated with laboratory contamination. However, because of the difficulty of verification of laboratory contamination, this compound will be included as an indicator.

Chlorinated Ethanes and Chlorinated Ethylenes - Rationale for Elimination: The following compounds were found with some frequency in the ground water

samples collected during the SRI and only in the NAPL during the RI: 1,1-dichloroethylene; 1,1-dichloroethane; 1,2-trans-dichloroethylene; tetrachloroethylene; and trichloroethylene. All were found at low geometric mean levels. Some higher levels were reported that are considered to be outliers (or in a NAPL). They are not included in the list of indicator chemicals due to their lower prevalence and chemical/toxicological similarity to 1,1,2-trichloroethane and 1,2-dichloroethane.

Chloroform - Rationale for Elimination: Chloroform was found not only in the NAPL during the RI, but also in 10 of 33 ground water samples collected from the NSCZ during the SRI. However, chloroform was found in a relatively small number of samples (25 of 180 samples analyzed) at low concentrations. Methylene chloride, a selected indicator chemical will serve as an adequate surrogate for the chlorinated methanes (chloroform).

Other Halogenated Aliphatic Hydrocarbons - Rationale for Elimination: Carbon tetrachloride; hexachlorobutadiene; hexachloroethane; 1,1,2,2-tetrachloroethane, and 1,1,1-trichloroethane were all detected infrequently (in one well). Therefore, they were not included on the indicator chemical list. Also, their toxicity as part of the class of halogenated aliphatic hydrocarbons is represented by the selected halogenated aliphatic hydrocarbons chosen as indicators.

#### 4.1.4.4 Chloroethers

Bis(2-chloroethyl)ether was found in pits, NSCZ ground water, and runoff to Mud Gully. The constituent was included on the indicator chemical list due to its prevalence and potential carcinogenicity. The chemical also represents the base/neutral constituents detected.

#### 4.1.4.5 Phthalate Esters

Phthalate Esters - Rationale for Elimination: Phtalate esters (bis (2-ethyl hexyl)phthalate and di-n-butyl phthalate) were not included on the indicator chemical list because of their infrequent occurrence.

## 4.2 SUMMARY OF INDICATOR CHEMICALS

The final indicator chemical list includes the following constituents found in the various environmental media during the RI and SRI and screened as explained above:

| | |
|---|---|
| Volatiles | • 1,2-dichloroethane<br>• 1,1,2-trichloroethane<br>• vinyl chloride<br>• methylene chloride |
| Base/Neutrals | • bis(2-chloroethyl)ether<br>• total PNA (non-carcinogenic)<br>• benzo(a)anthracene<br>• benzo(a)pyrene<br>• dibenzo(a,h)anthracene<br>• benzo(b)fluoranthene<br>• benzo(k)fluoranthene<br>• indeno(1,2,3-cd)pyrene |

## 4.3 CARCINOGENICITY AND TOXICITY OF THE INDICATOR CHEMICALS

Toxicity data for the indicator chemicals identified is given in the follow section.

### 4.3.1 Carcinogenicity Evaluation

The carcinogenicity data for the indicator chemicals is given in Tables 4-5 and 4-6. The carcinogenic potency factors q* recorded in Table 4-5 are at the upper 95 percent confidence limits on the slope of the dose-response curves derived from animal test studies. The values presented are from two sources, the Environmental Criteria and Assessment Office (Health Effects Assessment documents), U.S. Environmental Protection Agency (US EPA), Cincinnati, Ohio, and the Carcinogenic Assessment Group (CAG) of the US EPA.

Potency factors are used to estimate potential carcinogenic risk. These factors, specific to different exposure routes (ingestion and inhalation) are given in the reciprocal units of $(mg/kg/day)^{-1}$.

In addition, the unit cancer risk (UCR) for each chemical has been calculated in order to standardize the comparison. By definition, the UCR is the risk associated with exposure to 1 $\mu g/m^3$ in ambient air or 1 µg/liter in water for a lifetime of exposure by an adult man (70 kg body weight). For 1,2-dichloroethane the UCR via ingestion is $2.6 \times 10^{-6}$ (see Table 4-5).

TABLE 4-5
CARCINOGENICITY PARAMETERS
FOR INDICATOR CHEMICALS

| CATEGORY | CONSTITUENTS | POTENCY FACTORS $q^*$ | | UNIT CANCER RISK | UNIT CANCER RISK | $10^{-6}$ CANCER RISK | | $10^{-4}$ CANCER RISK | |
|---|---|---|---|---|---|---|---|---|---|
| | | INGESTION $(mg/kg/day)^{-1}$ | INHALATION $(mg/kg/day)^{-1}$ | (Ingestion) | (Inhalation) | INGESTION (DRINKING WATER) ug/l | INHALATION $ug/m^3$ | INGESTION (DRINKING WATER) mg/l | INHALATION $mg/m^3$ |
| Volatile | 1,1,2-Trichloroethene | $5.73 \times 10^{-2}$ | - | $1.64 \times 10^{-6}$ | - | 0.61 | - | 0.061 | - |
| Volatile | 1,2-Dichloroethane | $9.10 \times 10^{-2}$ | $3.50 \times 10^{-2}$ | $2.6 \times 10^{-6}$ | $1.14 \times 10^{-5}$ | 0.36 | 0.088 | 0.036 | 0.0088 |
| Volatile | Vinyl Chloride | 2.3 | $2.50 \times 10^{-2}$ | $6.6 \times 10^{-5}$ | $8.14 \times 10^{-6}$ | 0.015 | 0.12 | 0.0015 | 0.012 |
| Base/Neutral | Bis(2-Chloroethyl)Ether | 1.1 | - | $3.1 \times 10^{-5}$ | - | 0.032 | - | 0.0032 | - |
| Volatile | Methylene Chloride | $7.50 \times 10^{-3}$ | $1.43 \times 10^{-2}$ | $2.14 \times 10^{-7}$ | $4.66 \times 10^{-6}$ | 4.7 | 0.21 | 0.47 | 0.021 |

Note: To obtain the Unit Cancer Risk (UCR) level at exposure of 1 ug/l in water or 1 ug/$m^3$ in air:

$$\text{UCR ingestion} = \left(\frac{1\ ug}{liter} \times \frac{1\ mg}{1000\ ug} \times \frac{1}{70\ Kg} \times \frac{2l}{day}\right) \times q^* = \frac{2}{70{,}000}\, q^* = 2.86 \times 10^{-5}\, q^*$$

$$\text{UCR inhalation} = \left(\frac{1\ ug}{m^3} \times \frac{1\ mg}{1000\ ug} \times \frac{1}{70\ Kg} \times \frac{22.8m^3}{day}\right) \times q^* = \frac{22.8}{70{,}000}\, q^* = 3.26 \times 10^{-4}\, q^*$$

$$\text{and Concentration at } 1 \times 10^{-6} \text{ risk} = \frac{1 \times 10^{-6}}{UCR} \times (1\ ug/l) \text{ or } (1\ ug/m^3)$$

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TABLE 4-6
CARCINOGENICITY DATA AND WEIGHT OF EVIDENCE RATINGS
FOR INDICATOR CHEMICALS

| CATEGORY | CONSTITUENTS | LEVEL OF EVIDENCE(1) HUMAN | LEVEL OF EVIDENCE(1) ANIMAL | IARC GROUPING | EPA CATEGORIZATION ORAL | EPA CATEGORIZATION INHAL | TIER CATEGORY(2) | ORDER OF MAGNITUDE(3) (log 10 Index) | UNIT CANCER RISK x CONC. (PPB) |
|---|---|---|---|---|---|---|---|---|---|
| Volatile | 1,1,2-Trichloroethane | I | L | 3 | C | C | I | +1 | 79.9 |
| Volatile | 1,2-Dichloroethane | I | S | 2B | B2 | B2 | I | +1 | 101 |
| Volatile | Vinyl Chloride | S | S | I | A | A | I | 0 | 554 |
| Base/Neutral | Bis(2-Chloroethyl)Ether | I | S | 2B | B2 | B2 | I | +2 | 98. |
| Volatile | Methylene Chloride | I | L | 3 | B2 | B2 | I | -1 | 0.0235 |

(1)Level of Evidence for Carcinogenicity:
I = Insufficient
S = Sufficient
L = Limited
IARC & EPA categories described in text.

(2)Classification of chemicals for setting RMCLs (Fed. Reg. November 13, 1985).

(3)Reference: Clements Assoc. (Sept. 27, 1985)
"Chemical, Physical and Biological Properties of Compounds Present at Hazardous Waste Sites" under subcontract to GCA for EPA.

Mathematically, a $2.6 \times 10^{-6}$ cancer risk means that a person exposed to 1 µg/l of 1,2-dichloroethane by drinking the water for 70 years will have a 0.0000026 greater chance of getting cancer than an otherwise identical person not exposed at all. The usual method is to indicate that this would be 2.6 more cases than expected in a population of 1,000,000 due to exposure at that level.

The ingestion of drinking water and inhalation contaminant concentrations at the $1 \times 10^{-6}$ and $1 \times 10^{-4}$ cancer risk levels have been calculated and are also presented in Table 4-5.

The concentrations for the $1 \times 10^{-4}$ and $1 \times 10^{-6}$ cancer risk level are derived by dividing those risk levels by the UCR.

Table 4-6 is a compilation of Weight of Evidence ratings for the indicator chemicals detected in the NSCZ which are suspected and known animal and human carcinogens.

The weight of evidence is a measure of the strength of the classification assigned by the International Agency for Research in Cancer (IARC). Another is the US EPA carcinogenic classification defined in the guidelines for carcinogenic risk assessment (Federal Register, September 24, 1986, p. 34000) of the compounds listed.

Weight of evidence ratings qualify the level of evidence that supports designating a chemical as a human carcinogen. The IARC and EPA categories (see Table 4-7) for potential carcinogens are also given.

The tier category refers to the US EPA Office of Drinking Water scheme (Federal Register, June 12, 1984) for establishing priorities for setting RMCLs. Level III is the lower priority.

4.3.2 Subchronic and Chronic Toxicity

Inherent in the characterization of risk due to chronic exposure to toxic substances is the premise that there may be no threshold limit for suspected carcinogenic constituents. Also basic to the assessment procedure is the idea

TABLE 4-7
US EPA WEIGHT OF EVIDENCE
CATEGORIES FOR POTENTIAL CARCINOGENS

| CATEGORY | DESCRIPTION OF GROUP | DESCRIPTION OF EVIDENCE |
|---|---|---|
| Group A | Human Carcinogen | Sufficient evidence from epidemiologic studies to support a casual association between exposure and cancer |
| Group B1 | Probable Human Carcinogen | Limited evidence of carcinogenicity in humans from epidemiologic studies |
| Group B2 | Probable Human Carcinogen | Sufficient evidence of carcinogenicity in animals, inadequate evidence of carcinogenicity in humans |
| Group C | Possible Human Carcinogen | Limited evidence of carcinogenicity in animals |
| Group D | Not Classified | Inadequate evidence of carcinogenicity in animals |
| Group E | No Evidence of Carcinogenicity in Humans | No evidence for carcinogenicity in at least two adequate animal tests or in both epidemiologic and animal studies |

that, in the case of suspected carcinogenic materials, cancer risk may be the limiting factor for acceptability. Other health consequences due to chronic exposure to these substances may not be the critical factor. However, this report considers both aspects, i.e., chronic toxicity and carcinogenicity, if the data are available to do so.

Appropriate available chronic toxicity data that characterize the indicator chemicals found in the surface sediments and water are listed in Table 4-8. These are the lowest observed adverse effects levels (LOAELS) and health advisories developed by the US EPA Office of Drinking Water. Any effects, regardless of the severity of the health impact on the test animal, are reported and the given value is the lowest reported dose at which the health effect is exhibited (or LOAEL). Application of an uncertainty factor to the LOAELS, based on the quality of the data, is the method used to develop adjusted acceptable daily intakes (AADIs) or risk reference doses (RfDs).

Calculations were performed to determine the level of human exposure (i.e., amount of soil ingested) required to reach a toxic effect level. The conclusions are presented in Table 4-8 and discussed in the following paragraphs.

Chronic exposure, i.e., daily over a period of 18 months to two years, to the pit residues could result in health impacts if as little as 3 to 4 grams/day were ingested. However, while prolonged ingestion of pit residues could result in adverse health effects, exceedance of the lowest adverse health effect level and subsequent harmful effects would not occur at the estimated average daily ingestion rate of 0.062 gram. The constituents in the pit at maximum concentrations (those detected in RI Phase I samples) that approach the chronic toxicity levels include: 1,2-dichloroethane (at 245,000 mg/kg); 1,1,2-trichloroethane (at 166,000 mg/kg) and vinyl chloride (at 22,700 mg/kg). It is likely that these concentrations represent "hot spots" in the pits and thus this qualitative evaluation is very conservative.

Exposure of aquatic biota to maximum observed concentrations of 1,2-dichloroethane and 1,1,2-trichloroethane without dilution would have some effect due to chronic exposure. However, there is opportunity for sufficient dilution before and after the NSCZ ground water reaches Mud Gully. Neither acute nor chronic effects on aquatic biota are indicated.

TABLE 4-8
CHRONIC TOXICITY PARAMETERS
FOR THE INDICATOR CHEMICALS
BRIO/DOP SITE

| CONSTITUENT | MAXIMUM DETECTED CONCENTRATIONS | APPROPRIATE TOXICITY PARAMETER | REQUIRED HUMAN EXPOSURE LEVEL TO REACH TOXIC LEVE |
|---|---|---|---|
| 1,2-Dichloroethane | Pit Residues - 245,000 mg/kg | LOAEL 10 mg/kg/day | Ingestion of 3g residue |
| | Subsoils - 515 mg/kg | LOAEL 10 mg/kg/day | Ingestion of 1.4 kg soils |
| | * NSCZ(RI)GW - 3,580 mg/l | Chronic Aquatic - 20 mg/l | W/O dilution will exceed |
| | * NSCZ(SRI)GW - 15.3 mg/l | Chronic Aquatic - 20 mg/l | Will not exceed toxic level |
| 1,1,2-Trichloroethane | Pit Residues - 166,000 mg/kg | LOAEL 10 mg/kg/day | Ingestion of 4.2g residue |
| | Subsoils - 918 mg/kg | LOAEL 10 mg/kg/day | Ingestion of 1.4 kg soils |
| | NSCZ(RI)GW - 1,810 mg/l | Chronic Aquatic - 9.4 mg/l | W/O dilution will exceed |
| | NSCZ(SRI)GW - 217 mg/l | Chronic Aquatic - 9.4 mg/l | W/O dilution will exceed |
| Vinyl Chloride | Pit Residues - 22,700 mg/kg | LOAEL - 1.7 mg/kg/day | Ingestion of 5.2g |
| | * NSCZ(RI)GW - 1,080 mg/l | Chronic Aquatic - No Level | Will not be present in surface water |
| | * NSCZ(SRI)GW - 108 mg/l | Chronic Aquatic - No Level | at high concentrations. |
| Methylene Chloride | Pit Residues - 909 mg/kg | Chronic Aquatic - No Level Reported | Not quantifiable |
| | Subsoils - 58 mg/kg | * | |
| | * NSCZ(RI)GW - 110 mg/l | * | |
| | * NSCZ(SRI)GW - 20.9 mg/l | * | |
| Bis(2-Chloroethyl)Ether | * NSCZ(RI)GW - 42 mg/l | Chronic Aquatic - No Level Reported | |
| | * NSCZ(SRI)GW - 34 mg/l | | |

* The ground water in the NSCZ will not be ingested by human receptors. Therefore effects on aquatic biota are examined.
LOAEL - Lowest Observed Adverse Effects Level

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### 4.3.3 Acute Toxicity

Table 4-9 contains the toxicity parameters associated with acute exposures and an estimate of the required exposure level (single dose) needed to result in a toxic response.

Acute exposure to the pit residues, subsoils, surface soils and sediments will not result in any health effects via ingestion with the exception of ingesting pit residues containing 1,2-dichloroethane (at 245,000 mg/kg) and 1,1,2-trichloroethane (at 166,000 mg/kg) at the maximum observed concentrations. Ingestion of a half-pound of the residue, a very unlikely occurence, will reach the oral rat $LD_{50}$ dose reported in the Registry of Toxic Effects of Chemical Substances (RTECS). All of the other indicator chemicals do not appear to present a hazard in the single ingestion exposure scenario.

Indicator chemicals found at high concentrations in the NSCZ water will require dilution (or attenuation) in order to avoid lethal effects to aquatic biota. At the maximum observed levels in the NSCZ in samples collected during the RI and SRI, 1,2-dichloroethane at 3,580 mg/l and 1,1,2-trichloroethane at 1810 and 2170 mg/l and copper at 110 mg/l would exceed acute toxicity levels if no dilution or attenuation occurs. However, as discussed in Chapter 6, sufficient dilution would occur in Mud Gully to reduce concentrations below levels of concern. All of the other indicator chemicals were observed at maximum concentrations below the acute aquatic toxicity (96 hr $LC_{50}$) parameter.

### 4.3.4 Developmental and Reproductive Toxicity

Toxicological literature indicates that some of the indicator chemicals have exhibited developmental toxicity, i.e., they can induce structural and/or other abnormalities in the developing fetus. They also may have some impact on the male and female reproductive system. An evaluation of the reported effects of indicator chemicals and the dose needed to produce these effects indicates that relatively high doses are necessary to produce these effects.

Characterization of the developmental and reproductive toxicity of the indicator chemicals is presented in Table 4-10. In order to provide some site-specific perspective to the meaning of the health parameters, soil

TABLE 4-9
ACUTE TOXICITY PARAMETERS
FOR THE INDICATOR CHEMICALS
BRIO/DOP SITE

| CONSTITUENT | MAXIMUM DETECTED CONCENTRATIONS | APPROPRIATE TOXICITY PARAMETER | EXPOSURE DOSE NECESSARY TO REACH TOXIC LEVEL |
|---|---|---|---|
| 1,2-Dichloroethane | Pit Residues - 245,000 mg/kg | Oral rat $LD_{50}$ - 670 mg/kg | Ingestion of 0.19kg (.42 lbs.) residue |
| | Subsoils - 515 mg/kg | | Ingestion of 91kg (200 lbs.) subsoils |
| | * NSCZ-GW - 3,560 mg/l | Acute Aquatic - 118 mg/l | W/O dilution - exceeds toxic level |
| | (SRI) 16.3 mg/l | | Will not exceed toxic level |
| 1,1,2-Trichloroethane | Pit Residues - 166,000 mg/kg | Oral rat $LD_{50}$ - 500 mg/kg | Ingestion of 0.24 kg (0.53 lbs.) residue |
| | Subsoils - 918 mg/kg | | Ingestion of 44.2 (97 lbs.) subsoils |
| | * NSCZ-GW - 18,10 mg/l | Acute Aquatic - 81.7 mg/l | W/O dilution will exceed toxic level |
| | (SRI) 217 mg/l | | W/O dilution will exceed toxic level |
| Vinyl Chloride | Pit Residues - 22,700 mg/kg | Oral rat $LD_{50}$ - 500 mg/kg | Ingestion of 1.5 kg (3.3 lbs.) |
| | * NSCZ(SRI)GW - 108 mg/l | | Not quantifiable |
| Methylene Chloride | Pit Residues - 909 mg/kg | Oral rat $LD_{50}$ - 2156 mg/kg | Ingestion of 164.4 kg (362 lbs) residue |
| | Subsoils - 58 mg/kg | | Ingestion of 2,578 kg (5671 lbs) subsoils |
| | Surface Soils - 59 mg/kg | | Ingestion of 2,179 kg (5980 lbs) surface soils |
| | * NSCZ(RI)GW - 510 mg/l | Acute Aquatic - 224 mg/l | Will not exceed toxic levels |
| | * NSCZ(SRI)GW - 20.9 mg/l | | Will not exceed toxic levels |
| Bis(2-Chloroethyl)Ether | * NSCZ(RI)GW - 42 mg/l | Acute Aquatic - 238 mg/l | Will not exceed toxic levels |
| | * NSCZ(SRI)GW - | | |

*The ground water in the NSCZ will not be ingested by human receptors.

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TABLE 4-10
CHARACTERIZATION OF DEVELOPMENTAL
REPRODUCTIVE TOXICITY (INDICATOR CHEMICALS)

| CONSITUTENT | HEALTH PARAMETER | *SOIL (OR RESIDUAL) CONCENTRATION EQUIVALENT TO HEALTH PARAMETER |
|---|---|---|
| 1,1,2-Trichloroethane CAS No. 79-00-5 | None Available. | None Available. |
| 1,2-Dichloroethane 107-06-2 | (a)NOAEL=50 mg/kg/day mice. | $1.4 \times 10^{-7}$ mg/kg (or pure chemical). |
| Vinyl Chloride 75-01-4 | (a)NOAEL=2500 ppm (6500 $mg/m^3$) based on inhalation. | (b)Conversion. 2629 mg/day. Assume 50% is exhaled, effective dose 1315 mg/l $5.26 \times 10^{-6}$ (or Pure Chemical). |
| Methylene Chloride | (c)Based on inhalation LOAEL=15,600 $mg/m^3$ | (b)conversion to man: 7000 mg/day. 50% exh. $1.4 \times 10^{-7}$ mg/kg soil (Pure Chemical) |
| bis(2-chloroethyl)ether 111-44-4 | None Available. | None Available. |
| benzo(a)pyrene | (d)LOAEL=10 mg/kg/day | $2.8 \times 10^{-6}$ mg/kg soil (Pure Chemical) |

a. USEPA 1985 - Health Advisories for 52 Chemicals. NTIS PB86-338.

b. USEPA 1985a - Health Assessment Document for Chlorinated Benzenes EPA/600/8-84/015F. Calculation of Human Equivalent Dosages. Pages 12-96 to 12-91.

c. USDHHS(ATSDR) 1987 - Draft Toxicological Profile for Methylene Chloride.

d. USDHHS(ATSDR) 1987a - Draft Toxicological Profile for Benzo(a)Pyrene.

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concentrations were estimated that equal the chronic daily intake using the unrestricted use scenario described in Appendix F.

Exposure to the indicator chemicals at the observed concentrations in ambient air would not be expected to result in developmental health impacts. Inhalation of the volatile organics at high concentrations, such as occupational exposure levels, would be required to initiate developmental health effects. Ambient air concentrations would not reach these levels as long as the affected material and soil remain undisturbed. Ingestion of affected materials and soil from the site, at the maximum observed concentrations, will not exceed the lowest reported dose for reproductive and developmental toxicity. Ground water is not presently being used and therefore does not need to be evaluated for drinking purposes.

4.3.5 Dose-Response Relationships

Risk characterization, especially in cancer risk quantification, is highly dependent upon the determination of a maximum effective dose, which is defined as the concentration of the constituent that is absorbed. Thus, absorption rates through the lungs, gastrointestinal tract, and skin are critical in the quantification of the dose response.

PNAs are usually present as strongly absorbed films on the sediment/sand particles. Therefore, assuming that the indicator chemicals are totally bioavailable is an extremely conservative premise. For instance, animal tests have indicated that hexachlorobenzene in an aqueous carrier is absorbed at approximately six percent as compared to an 80 percent rate when administered in an oil carrier. For PNAs, a gastrointestinal absorption rate of 50 percent has been reported in the literature (EPA-HEA 1984). In the absence of data, a total absorption through the gastrointestinal tract is conservatively assumed for the other indicator chemicals in the exposure assessment portions of this EA. Benzo(a)pyrene and the other carcinogenic PNAs have high soil adsorption coefficients. Therefore, dermal absorption was estimated to be 0.3% and 3% for the probable and upper bound exposure scenarios. (Poiger and Schlatter, 1980).

### 4.3.6 Epidemiological Evidence

Epidemiological studies related to carcinogencity of the indicator chemicals are mostly associated with occupational exposure to the chemical. Most epidemiological evidence of PNA carcinogenicity in humans involved dermal and/or inhalation exposure of individual workers to PNA containing material (coal gas, tars, soot, and coke oven emissions). Those epidemiological studies conducted in residential areas associated with PNA-containing materials are inconclusive. The results of these studies are summarized in Appendix K.

A literature search was conducted in an attempt to identify environmental epidemiological studies of vinyl chloride. No epidemiological studies, other than occupational exposures, were found for this compound.

## 4.4 SUMMARY

This chapter, Hazard Identification, serves to focus the EA on a selected list of indicator chemicals that adequately represent the potential hazards associated with the site. The final indicator chemical list includes the following constituents:

| | |
|---|---|
| Volatiles | • 1,2-Dichloroethane |
| | • 1,1,2-Trichloroethane |
| | • Vinyl Chloride |
| | • Methylene Chloride |
| Base/Neutrals | • Bis(2-chloroethyl)ether |
| | • Total PNA (non-carcinogenic) |
| | • Benzo(a)pyrene |
| | • Dibenzo(a,h)anthracene |
| | • Benzo(b)fluoranthene |
| | • Benzo(k)fluoranthene |
| | • Indeno(1,2,3-cd)pyrene |
| | • Benzo(a)anthracene |

These constituents were described toxicologically, and appropriate quantitative indices of toxicity were developed for site-specific circumstances. These data will be used in Chapter 6 to quantify the hazard

component of the risk characterization. This chapter has also addressed exposure duration and type to establish the context for the exposure assessment that follows.

With the hazard component defined, the exposure assessment in Chapter 5 will provide the site specific details of the other component of risk, namely the exposure.

# 5.0 EXPOSURE ASSESSMENT

This chapter provides an assessment of the potential for exposure of receptors on or near the Brio/DOP sites. For identified receptors, a set of hypothetical pathways for exposure are defined. These pathways are assessed as to their plausibility or importance relative to public health or environmental considerations. Potentially important pathways are identified for subsequent, more detailed, characterization of risk (in Chapter 6).

## 5.1 RECEPTOR DEFINITION

The receptor definition provides an estimation of the expected degree of human population (or environmental) contact with the indicator chemical constituents. The receptor definition analysis involves the following four steps:

- Identification of exposed populations,
- Characterization of population,
- Analyses of population activities,
- Development of exposure coefficients.

The first step requires comparing data on distribution and potential mobility of site constituents with population data in order to identify and enumerate those populations (human and environmental) that may potentially or actually be exposed to the indicator chemicals. The second step, population characterization, involves identifying those groups (e.g., infants, elderly, women of child-bearing age, endangered or sensitive wildlife species) within the exposed populations which may experience a greater risk than the average population as a result of a given exposure level. The third step, activity analysis, involves an examination of the activities (e.g., employment, recreation) of potentially or actually exposed populations in order to define the extent or level of exposure of the previously identified and characterized populations.

The final step (Chapter 6, Current Risk Characterization) of the receptor definition analysis is the identification of hypothetical exposure coefficients. The exposure coefficient combines information on the frequency and magnitude of contact with constituents to yield a quantitative value of the amount of affected medium contacted per unit of time. Exposure coefficients are developed for each exposure route and are used as input to calculating the dose incurred. An example of an exposure coefficient would be the average daily intake of drinking water.

### 5.1.1 Land Use and Demographics

Much development has occurred in the area surrounding the Brio/DOP site in the past seven years. Details of land use and demographic factors as they relate to site receptors are presented in Appendix B. Several residential subdivisions, including Southbend (built between 1980 and 1984) at the northern site property line, have been developed. A junior college campus, an elementary school, and a hospital are also located approximately half a mile from the site.

Outside of the residential and commercial areas, land is used for grazing and for oil and gas production. Approximately 26 oil and gas wells are located near the site and several pipeline easements cross the site.

The 1985 population residing within a one-mile zone around the site is estimated as 5,751. Approximately 71,000 people reside within a four-mile radius of the site.

This population is composed mostly of young families. The distribution by sex is not significantly different than national figures. However, the number of persons under five years is three times the national average, while those 62 years or older is one-fourth the national average.

Most of the employed persons (over 16 years) are in managerial, professional, technical or administrative positions. Seventy-five percent of the residences are owner-occupied, single-family dwellings.

Public or private utilities supply water to 99.9 percent of the homes within one mile of the Brio/DOP site. The nearest municipal well is slightly over one mile from the site and is completed at a depth of 1,200 feet. This well produced over 63 million gallons in 1985.

Most of the other water wells located within a one-mile radius are owned by Exxon, and were constructed for various purposes related to oil and gas development. These wells are completed at depths ranging from about 100 feet to over 1,000 feet. There are seven other water wells within a one mile radius which are completed at depths of about 90 feet to several hundred feet. Wells on or closest to the site are over 400 feet deep.

### 5.1.2 Ecology

Surveys conducted on and near the Brio/DOP site found terrestrial fauna common to this region. Small mammals are predominately rodents. The aquatic biota near the site include annelid worms, leeches, and aquatic insects. Neighboring streams are not suited for diverse aquatic life due to low dissolved oxygen levels, wide temperature fluctuations and lack of suitable habitat. Mosquito fish, a particularly hardy species, dominates the fish population.

## 5.2 EXPOSURE PATHWAYS

As part of the EA, all known or hypothetical exposure pathways associated with the identified receptors were assessed to determine their significance. For a complete exposure pathway, three components must exist: a source of hazard, a route for constituent mobility to a receptor, and a receptor. A schematic of known or hypothetical pathways for the Brio/DOP site is presented in Figure 5-1.

Pathways considered are as follows:

- Ground water discharge to Mud Gully.
- Potential effects on drinking water supplies.
- Flow from the NSCZ to the Fifty-Foot Sand.
- Sediment or solute transport in runoff to Mud Gully.
- Volatile emissions.

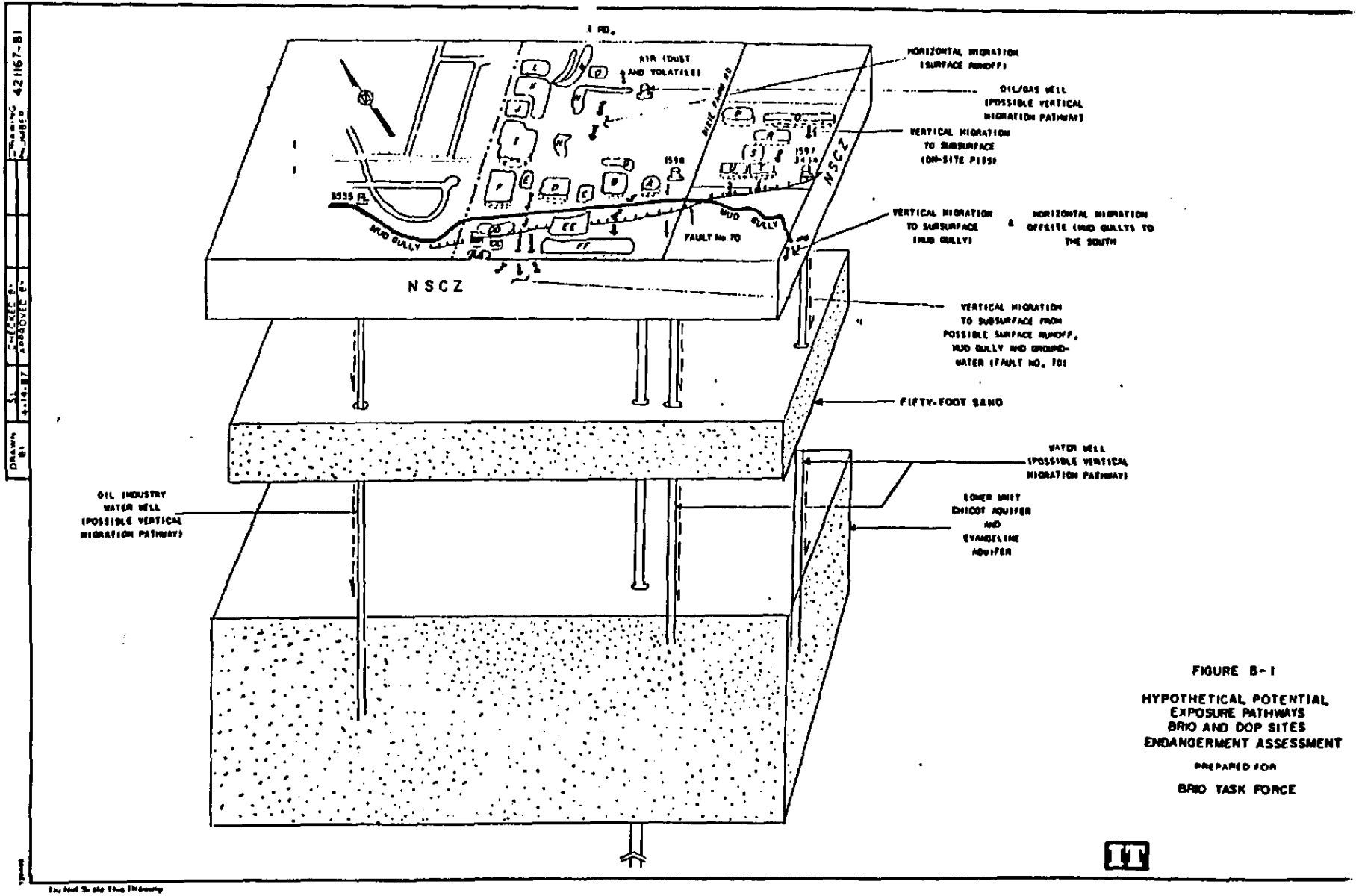


FIGURE B-1

HYPOTHETICAL POTENTIAL EXPOSURE PATHWAYS
BRIO AND DOP SITES
ENDANGERMENT ASSESSMENT

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- Soil ingestion and dermal exposure.
- Faults.
- Pipeline routes.

An evaluation of these pathways with respect to their impact on public health and the environment is discussed in the following subsections.

### 5.2.1 Ground Water Discharge to Mud Gully

The site is underlain by a shallow water-bearing zone designated the Numerous Sand Channel Zone (NSCZ). Effects of pit operations on the NSCZ have been observed in several monitor wells (especially in association with Pits B, J, and Q). The potentiometric surface maps indicate the flow in the NSCZ is toward Mud Gully. A migration pathway by which the on site consitutents can be transported to off site locations is the horizontal flow in the NSCZ towards Mud Gully. This pathway is examined in more detail in Section 6.3.

### 5.2.2 Potential Effects on Drinking Water Supplies

The NSCZ is not an existing or potential drinking water supply because of the poor yield of the aquifer. The Fifty-Foot Sand is a potential, but not a current, drinking water source. Based on demographic data, land use and projected water supply plans for the area, it does not appear that the Fifty-Foot Sand will be needed as a drinking water source.

The RI states that there are "no known uses of ground water from (the Fifty-Foot Sand) as a source of drinking water supply in the vicinity of the site". No drillers' logs exist in state or subsidence district records and, according to the well inventory (Appendix B), there are only two wells which are remotely close to being completed in the Fifty-Foot Sand. One is up gradient from-Brio/DOP and the other was used in the drilling of nearby oil/gas wells. Area residents receive water from municipal utilities and no known domestic water wells have been completed in the NSCZ or the Fifty-Foot Sand within a four-mile radius around the site.

A vertical upward gradient exists between the NSCZ and the Fifty-Foot Sand over most of the site. Reversal of the gradient is unlikely since it would require, for example, heavy ground water pumping of the Fifty-Foot Sand which is not currently utilized.

There are no surface drinking water intakes in the surrounding area. Drinking water sources in the area are mostly ground water supplied by Municipal Utility District and City of Houston wells completed in the Evangeline Aquifer (greater than 500 to 600 feet deep). Increases in pumping and installation of future wells are not expected, since demographic figures indicate a slower than average growth in the area as compared to the rest of the City of Houston, and a general trend away from utilizing ground water due to subsidence issues.

Two regional aquifers (Lower Chicot and Evangeline) lie at depths of 400 to 600 feet beneath the site and represent major drinking water supplies for residents in the Houston-Galveston County area. Available data indicate that the thickness of the clay aquitard between the Fifty-Foot Sand and the Lower Chicot/Evangeline is 100 to 120 feet and that the hydraulic conductivities of clay ranges from $1 \times 10^{-8}$ to $1 \times 10^{-10}$ cm/sec. From the available data it is concluded that it is highly unlikely for constituents to migrate vertically through the clay aquitard to the Lower Chicot/Evangeline aquifers.

Three water wells (1597, 1598, and 3434) are located on site (see Appendix B, Figure B-2). The existing gradient is upward between the Fifty-Foot Sand and NSCZ, and therefore these wells are not considered to be potential vertical pathways of water soluble chemical constituents to the deeper regional aquifers.

5.2.3 Flow From the NSCZ to the Fifty-Foot Sand

In order for organic compounds to move from the pits to the Fifty-Foot Sand, a downward hydraulic gradient must exist. Potentiometric readings from the NSCZ and the Fifty-Foot Sand are available for August and October, 1986 and for March, 1987. These data indicate that an upward hydraulic gradient between the NSCZ and the Fifty-Foot Sand exists over most of the Brio site (Figure 5-2).

However, the northern corner of the site does have an existing downward gradient. Evaluation of water level elevation maps indicates that the "transition zone" between upward and downward hydraulic gradients has an annual lateral shift of approximately 400 feet due to seasonal differences in recharge rate to the two aquifer zones.

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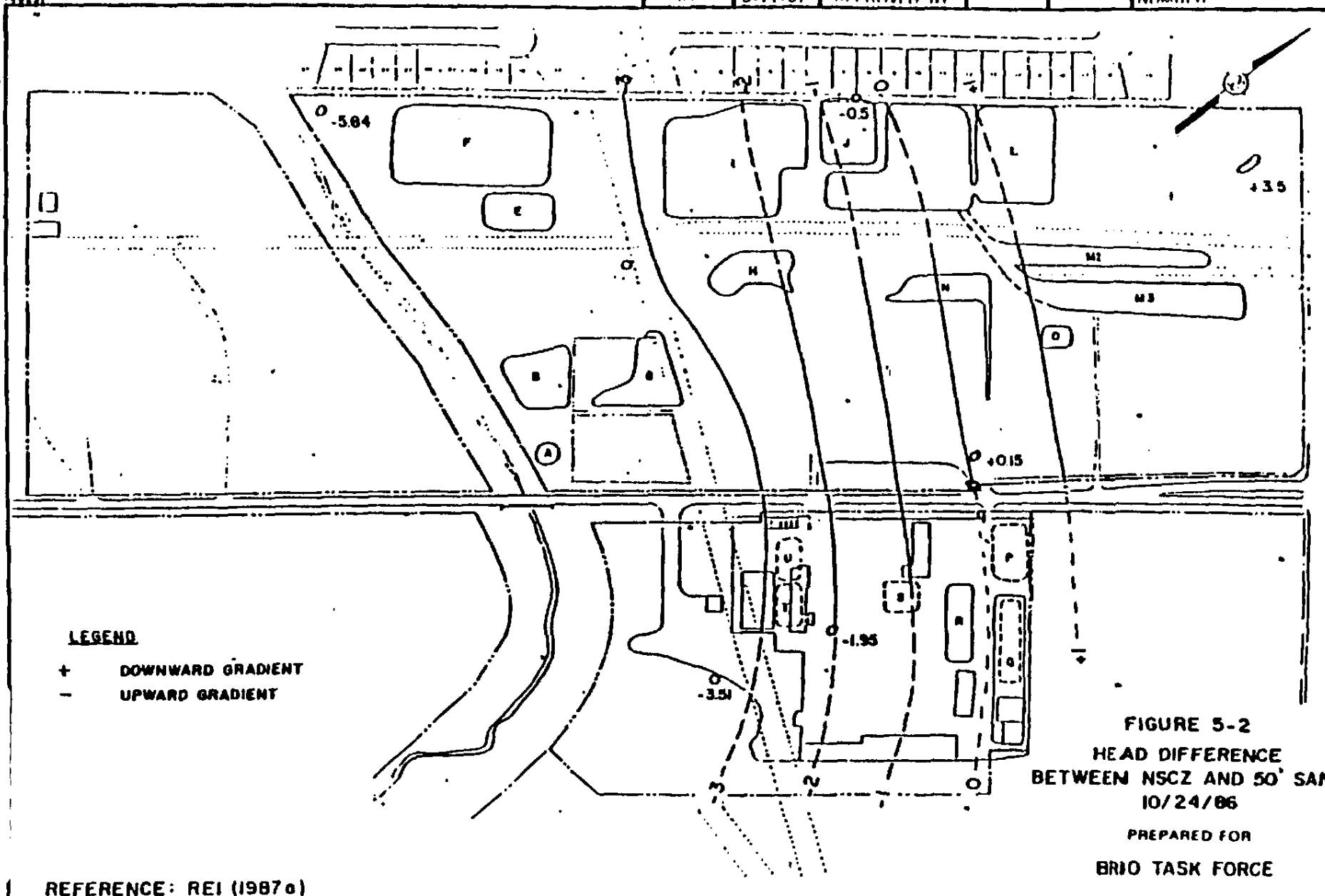


FIGURE 5-2
HEAD DIFFERENCE
BETWEEN NSCZ AND 50' SAND
10/24/86

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REFERENCE: REI (1987a)
REMEDIAL INVESTIGATION
ATTACHMENT 2B

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SCALE

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The potential for downward movement of constituents into the Fifty-Foot Sand increases as the vertical hydraulic gradient transition zone shifts towards Mud Gully and the extent of downward hydraulic gradients in the site area increases. The maximum extent of this condition has been observed in the October, 1986 potentiometric readings. At that time, the transition zone occurred about 200 feet to the north of Pit J. Pits L, M and O lie in the area where downward hydraulic gradients presently exist over most of the year. Pits J, K, N, P, Q and R are close enough to the observed transition zone that it is conceivable that downward hydraulic gradients may exist at certain times during the year in the area of these pits.

The present configuration of the vertical hydraulic gradients on site does not readily explain the observed constituent concentrations at BMW-13B. During the period when pits were open at the Brio/DOP site, there was an enhanced potential for infiltration into the NSCZ due to water ponding in the pits and the proximity of the NSCZ to the base of the pit excavations. The ponded water could mix readily with the materials in the pit which would result in elevated concentrations of soluble pit constituents in the leachate infiltrating into the NSCZ. It is likely that most of the presently observed organic constituent concentrations in the NSCZ entered the zone during the operational period. After pit closure the infiltration rates from the pits to the NSCZ would decrease dramatically. Concentrations of organic constituents in the NSCZ are therefore likely to have reached maximum levels in the vicinity of the pits during the operational period and are now generally decreasing due to the flushing effect of ground water flow in the unit.

The enhanced recharge from the pits during the operational period would also tend to elevate the potentiometric levels in the NSCZ in the vicinity of the open pits above normal levels. This could have lead to localized reversals of an upward vertical hydraulic gradient between the NSCZ and the Fifty-Foot Sand or enhancement of an existing downward gradient. Based on the measured transmissivities in the NSCZ and the probable maximum rate of pit infiltration, it is unlikely that NSCZ potentiometric levels would be increased by more than about one foot above natural levels by local pit recharge during the operational period (Appendix C).

Based on the above analysis, the maximum potential for movement of affected ground water into the Fifty-Foot Sand would have been during the operational period when downward hydraulic gradients and constituent concentrations in the NSCZ were at a maximum. Concentration levels in the NSCZ would tend to decrease following pit closure. Concentrations in the underlying Fifty-Foot Sand would reach a peak level some time after pit closure and then start to decrease as a result of natural attenuation.

The timing of the occurrence of peak concentrations in the Fifty-Foot Sand will be dependent on the rate of movement of affected ground water through the Middle Clay Unit which separates the NSCZ from the Fifty-Foot Sand. Given the naturally low hydraulic conductivity of the Middle Clay Unit, it is likely that the movement of ground water through the unit is relatively slow and that peak concentrations in the Fifty-Foot Sand may lag behind peak concentrations in the NSCZ by several years.

The potential for leakage from the NSCZ to the Fifty-Foot Sand was evaluated using mass balance techniques. A similar technique has been used to evaluate soil and ground water quality changes with time at the Sikes and French Limited Superfund sites. This evaluation is included in Appendix C. The steps involved in the evaluation are as follows:

- Estimate the rate of movement and constituent concentration of leachate infiltrating from a pit to the NSCZ.
- Calculate the dilution of the infiltrating leachate by natural flow in the NSCZ below the pit area and the resulting concentration of the constituent in the NSCZ.
- Calculate the excess potentiometric head in the NSCZ caused by infiltration from the pit and the resulting vertical hydraulic gradient between the NSCZ and the Fifty-Foot Sand.
- Calculate the rate of movement of affected ground water from the NSCZ to the Fifty-Foot Sand.
- Calculate the dilution of the affected ground water entering the Fifty-Foot Sand by natural flow in this unit below the pit area and the resulting concentration of the constituent in the Fifty-Foot Sand.

The calculations were performed on a year-by-year basis to allow conditions to be changed and to evaluate concentration variation in the NSCZ and Fifty-Foot Sand (Appendix C).

The model was calibrated to reproduce observed constituent concentrations by assuming reasonable ranges of values for the various parameters involved in the calculation. The results indicate that constituent concentrations are expected to decrease over time due to natural flushing in both units. Concentrations of these constituents in the Fifty-Foot Sand should reduce to MCLs, $10^{-5}$ risk levels or detection limits within ten to fifteen years due to natural attenuation (Appendix C). This evaluation does not include the long-term impact of DNAPLs perched on the Middle Clay unit.

Denser than water, non-aqueous phase liquid (DNAPL) was detected in wells BMW-13A and BMW-18A during the RI and also in later samples taken in August 1987. A layer of heavier-than-water DNAPL approximately four to six inches thick was found at the base of the NSCZ at both these well sites. The existence of an NAPL containing concentrated organic solvents, in contact with the Middle Clay Unit, indicated the possibility of chemical and physical alteration of the clay material which could lead to increased permeability. This might allow a localized increase in movement of organic constituents through the Middle Clay Unit and into the Fifty-Foot Sand given the appropriate physical conditions that would allow downward groundwater flow through the unit.

Several studies have been performed to assess the influence of organic solvents on clay materials. Dilute concentrations of organic solvents (<5%) have been found to have no detrimental influences on permeability of natural clay soils and more commonly cause a decrease in permeability (Daniel and Liljestrand, 1984). Nearly all the published data indicate that the permeability of clay to concentrated solvents is 10 to 1000 times higher than that to water. However there are some conflicting data that suggest that the method of testing employed in many of these studies contributed to most of the observed permeability increase and in reality the influence of concentrated organic solvents on clay permeability is much less significant.

An extensive study reported by Anderson, Brown and Green (1982) involved permeation of four compacted clays with water and with seven organic solvents. The permeability tests were performed using a compaction-mold permeameter which does not allow the application of a confining stress. This simulates soil conditions at the ground water with zero overburden pressure. The soils were permeated in the molds using hydraulic gradients as large as 370. With most organic liquids, a large increase in permeability of up to three orders of magnitude was observed beginning at about 0.1 pore volumes of flow. Collapse of the diffuse-double layer of adsorbed cations, shrinkage cracking and piping have been postulated as the mechanisms controlling the increase in permeability.

There is considerable test data to support the conclusion that clays will shrink if the pore water is replaced with liquids having a lower dielectric constant (Murray and Quirk, 1982; Barshad, 1952). The dielectric constants of nearly all organic solvents range from two to 50 times lower than water and would therefore be expected to cause clays to shrink. The work by Anderson et al. has been criticized on the grounds that sidewall leakage in the rigid-wall permeameters used in the study may have led to anomalously large values of permeability for soils that underwent shrinkage when exposed to organic solvents. In addition, the elevated hydraulic gradients used in the study may have magnified the tendency for piping.

Permeability tests of clay soils with organic solvents performed in flexible-wall permeameter with applied confining stress indicate very different results from those reported by Anderson et al. Hamilton et al. (1983) found a negligible increase in permeability of a clay soil to pure acetone when under a confining pressure of 10 psi. The same soil exhibited a permeability increase of almost two orders of magnitude when the test was performed in a fixed-wall permeameter with no confining stress. Ongoing studies by Daniels and Liljestrand for the US EPA indicate that the permeability of kaolinite to methanol is approximately 10 times higher in fixed-wall permeameters compared with flexible-wall permeameters. It appears that applied stress conditions have a major influence on permeameter test results where shrinkage of the clay is likely.

A confining pressure of approximately 15 psi is usually applied in flexible-wall permeameter tests. This is equivalent to about 20 to 30 feet of overlying soil. The confining pressure apparently reduces the ability for the clay materials to develop shrinkage cracks when exposed to organic solvents. Overburden pressure will probably have a similar influence in the field. Permeability tests under varying confining pressures have been performed by Daniels and Liljastrand as part of ongoing studies. For an assumed unit weight of overburden material of 120 pounds per cubic foot, the following results were obtained for kaolinite permeated with methanol:

| Equivalent Overburden Thickness (ft.) | Permeability (cm/sec) |
|---|---|
| 2 | $2.1 \times 10^{-6}$ |
| 6 | $3.9 \times 10^{-7}$ |
| 15 | $3.2 \times 10^{-9}$ |

It seems clear that overburden pressure does have a large influence on the permeability of kaolinite to concentrated methanol.

The results of the ongoing studies by Daniel and Liljestrand for the US EPA are probably more appropriate than that of Anderson et al. (1982) for the conditions in the vicinity of wells BMW-13A and BMW-18A at the Brio/DOP site. At these locations, the Middle Clay is under about 40 feet of overburden confining pressure and the hydraulic gradients across the unit are generally less than 0.2 and in an upward direction. The potential for permeability increase in the Middle Clay Unit as a result of exposure to concentrated organic solvents is therefore likely to be relatively low.

If significant permeability modification of the Middle Clay Unit had taken place, much higher organic concentrations in the Fifty-Foot Sand would be expected adjacent to Pit J than are currently observed.

Given current state of the art understanding of the effect of solvents on clay permeability, the long-term effect of the sinking NAPL on the Middle Clay unit can not be predicted.

A quantitation of the health risks associated with the detected constituents in the Fifty-Foot Sand aquifer is included in Appendix G.

5.2.4 Sediment or Solute Transport in Runoff to Mud Gully

Mud Gully passes through the site. The site facilities and ponds are located immediately to the north and south of Mud Gully. Surface water drainage over most of the site flows into Mud Gully (Figure 5-3). Therefore, the gully is the first surface water receptor pathway for materials flowing off site in runoff.

Approximately 2,000 feet downstream, Mud Gully flows into Clear Creek, which then, approximately 12 miles downstream, discharges into Clear Lake. Finally, five miles further downstream, Clear Lake flows into Galveston Bay.

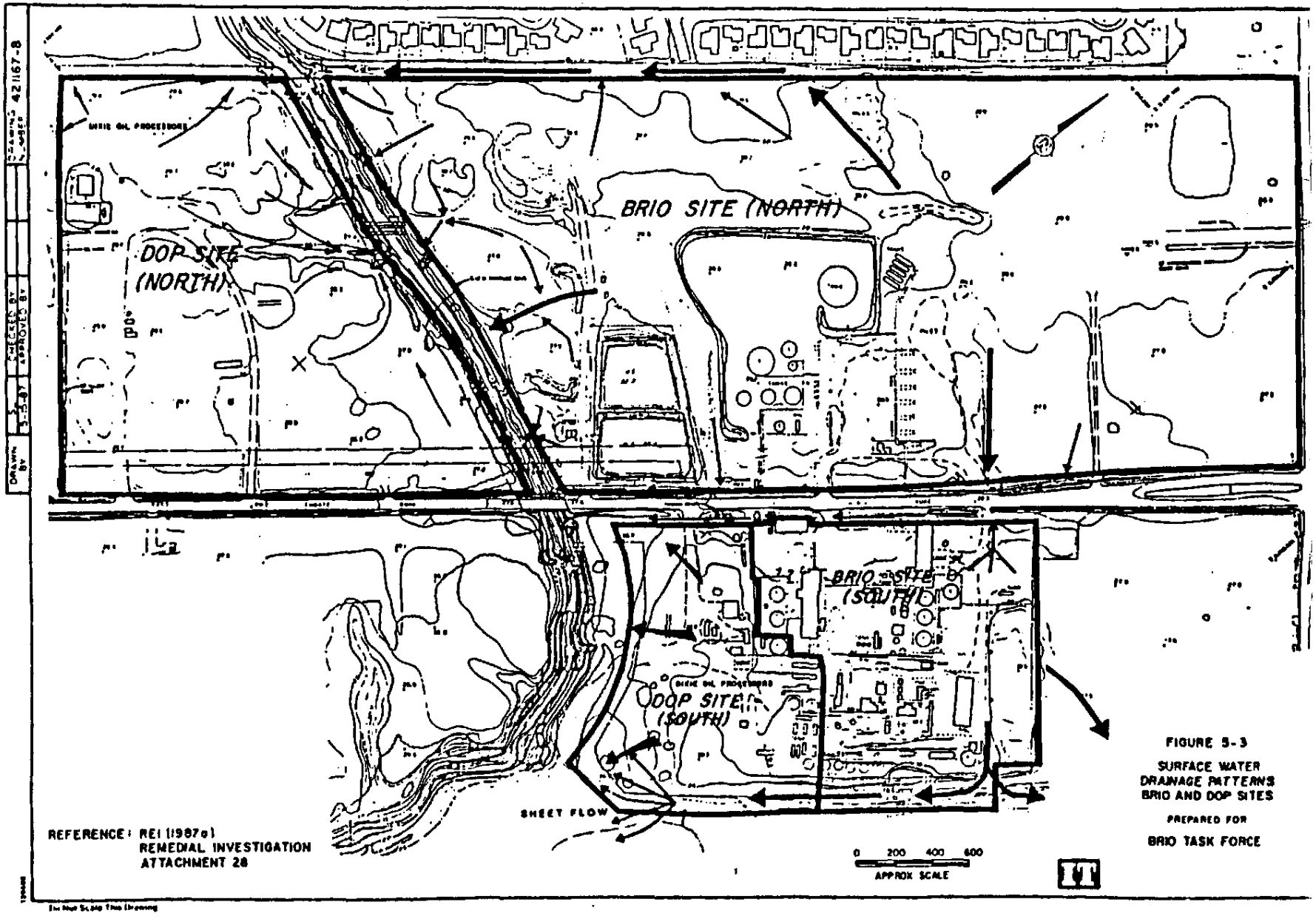
Secondary exposure due to recreational use of surface water is not expected to be a viable human exposure pathway due to the low levels of non-persistent volatile constituents detected in surface water analyses and the distance to hypothetical receptors. Distance and expected surface water mixing and turbulence will likely decrease soluble constituents in runoff to insignificant levels before reaching any recreational areas. In addition, the site itself is vegetated, is relatively flat and does not appear to be particularly subject to water and wind erosion. However, since there is a potential for off-site exposure and since low concentrations of base/neutral compounds and metals were detected in Mud Gully sediments, this pathway will be evaluated further in the risk characterization, Section 6.2.

5.2.5 Volatile Emissions

Prevailing winds in the site vicinity are southeasterly over populated areas. Close proximity of human receptors in the vicinity of the site and the presence of volatile constituents on site would indicate that there is some potential for inhalation exposure. A risk characterization of the air pathway is presented in Section 6.1.

5.2.6 Soil Ingestion and Dermal Exposure

Brio is bordered by a residential area. During the SRI surface soil samples (depth 0-1 foot and 9-10 feet) were collected from backyards adjacent to the




REFERENCE: REI (1987a)
REMEDIAL INVESTIGATION
ATTACHMENT 2B

FIGURE 5-3
SURFACE WATER
DRAINAGE PATTERNS
BRIO AND DOP SITES
PREPARED FOR
BRIO TASK FORCE

RSV 0018509

site. These off site residential soil samples indicate no significant impact. (Section 2.2.4.2)

Exposure to constituents via ingestion of soil (and dust) can occur by inadvertent consumption of soils on the hands, on tools or other objects, from nail biting, consumption of soil itself (pica), or by a combination of these routes. The soil ingestion pathway is typically only important for certain populations-at-risk, for example, children playing outdoors. This pathway is discussed in the risk characterization, Section 6.2.

5.2.7 Faults

During the RI, a study was performed of Fault No. 70 which runs generally east-west across the DOP site. The fault may have influenced the alignment of Mud Gully and has some effect on local ground water elevation.

If the fault intersects affected ground water or affected subsurface materials, the integrity of aquitards could be influenced. With observed upward vertical gradients in this area of the site, there is no potential for vertical migration to deeper aquifers.

The upward vertical gradient between the Fifty-Foot Sand and the NSCZ under the DOP site shows that Fault No. 70 has a low potential as a pathway for contaminants. This, along with the lack of evidence of significant effects on the local hydrogeologic system, indicates that this is not an important exposure pathway at this site.

5.2.8 Pipeline Routes

During the SRI a trench was excavated to expose the Friendswood Refining Pipeline located on the northeast side of the Brio North site. The 10-foot deep, 8-inch diameter carbon steel pipeline was investigated to determine if it might present a potential horizontal off site migration pathway.

The chemical analytical results indicate minimal concentrations of four constituents in the ground water (not surface water) samples in the pipeline backfill. Analyses for volatiles and base/neutral priority pollutant compounds were all non-detectable except for low µg/l concentrations of: two

volatiles; 1,1,2-trichloroethane (15.2 µg/l); vinyl chloride (11.7 µg/l); and two non carcinogenic PNAs; acenaphthene (9.06 µg/l), and fluorene (5.57 µg/l). 1,1,2-trichloroethane and vinyl chloride are very water soluble and consequently have a high probability of being detected in an aqueous medium. The low concentrations detected would indicate little migration of site constituents via this pathway. In addition, the backfill material is clay (not sand). The low permeability of the clay backfill will further retard any potential migration of constituents detected in the backfill ground water.

Based on the chemical analytical data, the conclusion is made that the pipeline does not appear to be a significant pathway for horizontal off site migration of site constituents.

## 5.3 SUMMARY

Potential exposure pathways associated with the Brio/DOP site representing possible risks to public health and the environment are:

- volatile emissions with potential effects on ambient air quality,
- dermal contact with or ingestion of surface soils and sediments,
- ground water discharge to Mud Gully with potential effects on aquatic life.

The risks associated with these pathways are evaluated in more detail in Chapter 6.