

**PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY
SUNBURST, MONTANA**

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SUBMITTED BY: Chevron Environmental Management Company

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List of Abbreviations and Acronyms

APH	air-phase hydrocarbon
ARM	Administrative Rules of Montana
ASC	asphalt, slag, cinder
AST	above-ground storage tank
AWWA	American Water Works Association
BETX	benzene, ethylbenzene, toluene, xylene
BLM	Bureau of Land Management
BNSF	Burlington Northern Santa Fe Railway
BTAG	Biological Technical Assistance Group
CEMC	Chevron Environmental Management Company
cm	centimeters
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CH ₄	methane
CKD	cement kiln dust
CLP	Contract Laboratory Program
CO ₂	carbon dioxide
COC	Chain of Custody
COI	constituent of interest
CSM	conceptual site model
DO	dissolved oxygen
DV	data validation
E&E	Ecology and Environment, Inc.
EM	electromagnetic

List of Abbreviations and Acronyms (cont.)

EPH	extractable petroleum hydrocarbons
ERA	Ecological Risk Assessment
°F	degrees Fahrenheit
FAQs	Frequently Asked Questions
FID	flame ionization detector
FS	Feasibility Study
FSP	Field Sampling Plan
ft-amsl	feet above mean sea level
ft-bgs	feet below ground surface
FWP	Fish, Wildlife, and Parks
GIS	geographic information system
glpg	gram lead per gallon
gpd-ft	gallons per day per foot
gpm	gallons per minute
gpm/ft	gallons per minute per foot
GC/FID	gas chromatography-flame ionization detection
GCLs	geosynthetic clay liners
GC/MS	gas chromatography-mass spectrometry
gpd	gallons per day
GPS	Global Positioning System
HHS	Human Health Standard
IDs	identifications
in-bgs	inches below ground surface

List of Abbreviations and Acronyms (cont.)

IHR	Industrial Hygiene Resources
LNAPL	light non-aqueous phase liquid
LSSI	Limited Scoping Subsurface Investigation
MA	Massachusetts
MADEP	Massachusetts Department of Environmental Quality
MBOG	Montana Board of Oil and Gas
MCA	Montana Code Annotated
MCLs	maximum contaminant levels
MDEQ	Montana Department of Environmental Quality
MDHES	Montana Department of Health and Environmental Sciences
MDL	method detection limit
mg/L	milligrams per liter
mg/kg	milligrams per kilogram
mg/m ³	milligrams per cubic meter
ml/min	milliliters per minute
MNA	monitored natural attenuation
MPE	multi-phase extraction
MPVE	multi-phase vacuum extraction
MSDS	Material Safety Data Sheet
MT	Montana
NRIS	Natural Resource Information System
ND	not detected
O ₂	oxygen

List of Abbreviations and Acronyms (cont.)

O&M	Operation and Maintenance
ORP	oxygen reduction potential
OSWER	Office of Solid Waste and Emergency Response
PAH	polynuclear aromatic hydrocarbons
Pb	lead
PCBs	Polychlorinated Biphenyls
PH&F	Pacific Hide and Fur
%	percent
PID	photoionization detector
ppm	parts per million
PQL	practical quantitation limit
PRAO	preliminary remedial action objective
PRG	preliminary remediation goal
PVC	polyvinyl chloride
QA/QC	quality assurance/quality control
QAPP	Quality Assurance Project Plan
RAA	Risk Assessment Addendum
RBCA	risk-based corrective action
RBSL	risk-based screening levels
RCRA	Resource Conservation and Recovery Act
RI	Remedial Investigation
RL	reporting limit
RMSL	RCRA Metals Screening Levels

List of Abbreviations and Acronyms (cont.)

ROW	Right of Way
RSI	Residential Soil Investigation
RSL	Regional Screening Level
SAP	Sampling and Analysis Plan
SCS	Soil Conservation Services
SI	Supplemental Investigation
SIM	Selective Ion Monitoring
SLs	screening levels
SOW	Scope of Work
SRG	straight-run gasoline
SSD	sub-slab depressurization
SSLs	Soil Screening Levels
SVE	soil vapor extraction
SVOC	semi-volatile organic compound
SW	Solid Waste
TCLP	Toxicity Characteristic Leaching Procedure
TDD	Technical Directive Document
TDS	total dissolved solids
TEH	total extractable hydrocarbons
TICs	tentatively identified compounds
TOV	total organic vapor
TPH	total petroleum hydrocarbons
TTHM	total trihalomethanes

List of Abbreviations and Acronyms (cont.)

UCL	Upper Confidence Limit
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
USTs	underground storage tanks
VCP	Voluntary Cleanup Plan
VI	vapor intrusion
VOC	volatile organic compound
VPH	volatile petroleum hydrocarbons
vs	versus
WET	Water & Environmental Technologies
WSF	water-soluble fraction
XRF	x-ray fluorescence

1.0 GENERAL INTRODUCTION

The Chevron Environmental Management Company (CEMC) conducted a Phase II Remedial Investigation (“Phase II RI”) for the former Texaco Sunburst Works Refinery (“the former refinery”), as required by the Montana Department of Environmental Quality (MDEQ) in their correspondence dated May 16, 2008 (Appendix 1-A). Note that Texaco, Inc. combined with Chevron Corporation on October 9, 2001, to form ChevronTexaco Corporation. In 2005, ChevronTexaco officially changed its name to Chevron Corporation. Texaco Inc. is currently a Delaware Corporation and a wholly owned subsidiary of Chevron Corporation. CEMC (a subsidiary of Chevron Corporation) is appointed as the attorney-in-fact for Texaco Inc., for managing environmental investigation and remediation activities. CEMC may be used interchangeably with Texaco and/or ChevronTexaco in the remainder of this document and in the accompanying appendices.

Citing findings from previous investigations (summarized in Section 1.4 of this document and more fully described in Appendix 1-B, Facility Operating & Prior Investigations History), MDEQ requested in their May 16, 2008 correspondence that a Phase II RI be conducted at the former refinery. Note that in this document, “the former refinery” is typically used when referring to areas within the original footprint of the former refinery site. The term “Facility” includes the former refinery site and also includes any area where a hazardous or deleterious substance from the former refinery has been deposited, stored, disposed of, placed, or otherwise come to be located.

The purpose of the Phase II RI was to define nature and extent of impacts from the former refinery, i.e., to determine Facility boundaries. MDEQ’s May 16, 2008 correspondence included a Scope of Work (SOW) that outlined the tasks to be completed as part of the Phase II RI. A document entitled *Phase II Remedial Investigation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (Phase II RI Work Plan) was submitted to MDEQ on September 15, 2008. MDEQ subsequently provided comments to the Phase II RI Work Plan on May 26, 2009. This and subsequent MDEQ correspondence, dated September 22, 2009, May 14, 2010, July 8, 2010, and October 15, 2010, further refined and expanded tasks to be completed as part of the Phase II RI. Copies of MDEQ correspondence are included in Appendix 1-A.

CEMC prepared several documents in response to the MDEQ requests which outlined the procedures to be used during the RI:

- Data Collection Activities for Updating Conceptual Site Model, Former Texaco Sunburst Works Refinery, Sunburst, Montana (CEMC 2009e) (“CSM Work Plan”)

- Phase II Remedial Investigation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana (CEMC 2010f) (“RI Work Plan”)
- Phase II Remedial Investigation Soil Sampling Step-Out Locations, Former Texaco Sunburst Works Refinery, Sunburst, Montana, November 5, 2010 (CEMC 2010g)

Activities described in the above documents commenced in September 2009 and continued through April 2012. A summary of the activities conducted between September 2009 and March 2010, and an evaluation of the data generated during this timeframe, were presented in the documents entitled *Conceptual Site Model Update, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, (CEMC 2010a) (“CSM Update Report”) and *Addendum to Conceptual Site Model Update, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, (CEMC 2010d) (“CSM Update Addendum”). Information presented in the CSM reports provided some of the basis for investigation activities outlined in the final Phase II RI Work Plan, dated July 22, 2010 (CEMC 2010f).

MDEQ provided CEMC with comments on the CSM Update Report and CSM Update Addendum via correspondence dated February 22, 2011 and May 2, 2011, respectively. CEMC provided responses to those comments via correspondence date August 2, 2011. That correspondence reiterated discussions with MDEQ during which it was agreed CEMC would present an in-depth CSM within the Phase II RI Report rather than incorporate comments on the CSM Update Report and CSM Update Addendum into an Integrated CSM Report. It was further agreed CEMC would incorporate commentary from both the CSM Update and Addendum Reports into the development of the Phase II RI Report and the updated CSM included with that document.

The remaining investigation activities as outlined in the final Phase II RI Work Plan were conducted between August 2010 and April 2012, including several activities which expanded the scope of the investigation as required in the MDEQ correspondence dated October 15, 2010. Note that while the three CEMC documents listed above document the majority of procedures utilized to conduct the Phase II RI, separate work plans and reports were prepared to address certain tasks associated with the Phase II RI SOW. These documents and their relationship to the documents and correspondence referenced above will be discussed in greater detail in corresponding sections of this RI Report. Additionally, the various documents prepared and the correspondence and communications that occurred throughout the Phase II RI are discussed in greater detail in Appendix 1-B, Facility Operating & Prior Investigations History.

The purpose of this document (“Report”) is to provide a comprehensive summary of activities conducted as part of the Phase II RI, present the results from said investigation activities, and provide recommendations for possible future activities at the Facility. Additionally, as indicated in the August 2, 2011 CEMC response to MDEQ comments on the

CSM Update Report and CSM Update Addendum, said comments are addressed within this document. A draft version of this Report was submitted to MDEQ on August 31, 2012, for review and comment. MDEQ provided comments on the draft version of the Report on April 3, 2013, and this revised Report incorporates changes made to address those comments.

1.1 PHASE II REMEDIAL INVESTIGATION OBJECTIVES AND REPORT ORGANIZATION

The primary objective of the Phase II RI was to define the nature and extent of impacts from former refinery operations, establish Facility boundaries, and better define the Facility's Conceptual Site Model (CSM). In addition, data collected during the Phase II RI will be used in part to support development of a Risk Assessment Addendum (RAA) for the Facility and initiate the Feasibility Study (FS) process.

This document has been organized to follow the same general format as the MDEQ May 16, 2008 SOW, in that media-specific activities are presented in individual sections similar to the task groupings and/or combinations utilized in the SOW. The placement of a task within a chapter or section does not necessarily reflect the level of effort associated with investigation activities for a specific task. The remaining sections of this RI Report include summaries of investigation procedures, field analyses, analytical results, an updated CSM and conclusions and recommendations for additional studies.

Specifically, this Report is structured as follows:

- Chapter 1.0 – Provides a general introduction, discusses the objectives of the Phase II RI, RI Report organization, and provides general information about the former refinery, including location, physical characteristics and natural feature, and former refinery operating and regulatory history.
- Chapter 2.0 – This chapter provides summaries of the general investigation methodologies utilized during the Phase II RI and which are outlined in greater detail in the referenced work plan documents. It also summarizes the procedures used to validate data generated during the Phase II RI and the data evaluation process used to determine nature and extent of impacts from the former refinery.
- Chapter 3.0 – This chapter summarizes the investigation activities conducted to determine nature, extent and degree of impacts to surface and subsurface soils, in specific areas defined by MDEQ in their May 16, 2008 and subsequent correspondence. Investigation methodologies that differ from those described in Chapter 2.0 due to the specific nature of the area being investigated or as intentional/unintentional deviations from respective work plan, are discussed in the area-specific

sections of this chapter. This chapter also presents data validation and data evaluation results for each area investigated.

- Chapter 4.0 – This chapter summarizes the investigation activities conducted to determine nature, extent and degree of impacts to groundwater. Investigation methodologies that differ from those described in Chapter 2.0 are discussed in this chapter. This chapter also presents data validation and data evaluation results, discusses groundwater classification for the Facility and makes recommendations for future monitoring activities.
- Chapter 5.0 – This chapter summarizes the investigation activities conducted to determine nature, extent and degree of impacts to surface water and sediment. Investigation methodologies that differ from those described in Chapter 2.0 are discussed in this chapter. This chapter also presents data validation and data evaluation results for surface water and sediment areas investigated.
- Chapter 6.0 – This chapter summarizes the investigation activities conducted to determine nature, extent and degree of impacts to “additional media” as defined by MDEQ in their May 16, 2008 and subsequent correspondence and presents the results from those activities.
- Chapter 7.0 – This chapter updates the Conceptual Site Model for the Facility that was presented in the CSM Update Report.
- Chapter 8.0 – This chapter summarizes additional studies related to the FS process and interim actions conducted during the Phase II RI.
- Chapter 9.0 – This chapter presents conclusions of the Phase II RI, provides recommendations for additional studies, and a schedule for activities and document submittal associated with the remainder of the RI/FS process.
- Chapter 10.0 – References.

1.2 FORMER REFINERY SITE INFORMATION

The following sections provide summary information regarding the former refinery location, physical layout, natural setting and features, and refinery operating history. Portions of this information were first presented in Section 2.1 of the *Site History Report, Texaco Sunburst Works Refinery Site, Sunburst, Montana* (TRC 1990a).

1.2.1 FORMER REFINERY LOCATION

The former refinery is located largely within the incorporated limits of the Town of Sunburst in Toole County, north-central Montana, approximately eight miles south of the Canadian border. The former refinery property is

adjacent to the southern part of the town and consists of approximately 380 acres west of Interstate 15 in parts of Sections 17, 18, and 19, Township 36 North (T36N), Range 2 West (R2W) (Figure 1.2-1). The approximate center of the former refinery is situated at latitude 48 degrees, 52 minutes, and 30 seconds, and longitude 111 degrees, 55 minutes, and 0 seconds.

The residential portion of the incorporated limits of the Town of Sunburst is bounded on the east by the Burlington Northern Santa Fe railroad tracks and on the south by the former refinery, and extends approximately 2,000 feet west of the railroad. As a side note, Burlington Northern Railroad was formed by the 1970 merger of four companies, including Great Northern Railway, and is now the Burlington Northern Santa Fe Railway Company (BNSF). Some site documents and maps referenced in this Report refer to the former Great Northern Railway tracks, which are the same as the BNSF tracks. Additionally, "Burlington Northern" and BNSF may be used interchangeably throughout this document to refer to the railway tracks.

The north-south oriented BNSF right-of-way separates the process and tank farm areas located west of the railroad from the wastewater treatment area east of the railroad. Interstate 15 lies east of the former refinery and is the major highway in the area.

The former refinery is located in an area of limited land use. Within a one-mile radius of the former refinery property, approximately 9 percent of the land is residential or light commercial in use and 11 percent is used for dry-land farming. Forty-seven percent of the land is largely undeveloped and approximately 14 percent is occupied by an intermittent unnamed lake. The former refinery covers approximately 19 percent of the one-mile radius area. Other significant land uses near the former refinery include the Sunburst municipal sewage lagoons (11 acres) southeast of the former refinery, a limited access airstrip (18 acres), and the former Cenex pipeline station (20.6 acres) at the southeast corner of the tank farm area west of the railroad tracks. The unnamed lake bed covers approximately 291 acres east of the railroad right-of-way. Several petroleum pipelines and associated right-of-ways historically ran through and adjacent to the former refinery property.

1.2.2 REFINERY OPERATING HISTORY

The history of the former refinery was first presented in the *Site History Report, Texaco Sunburst Works Refinery Site, Sunburst, Montana* (TRC 1990a). The following text is a summation of Section 2.1 of that document.

L.B. and John O'Neil started the first refining operations in Sunburst in 1924, taking advantage of its proximity to the Kevin-Sunburst Oil Field located four miles south. The Kevin-Sunburst Field produced medium- to heavy-gravity

crude from depths ranging from 700 to 1,500 feet below ground surface (ft-bgs). The O'Neal operation began as a crude oil refinery with a 500-barrel-per-day capacity and covering 9.31 acres. In 1926, the refining capacity was increased to 1,200 barrels per day, and the O'Neils reportedly sold their interests to the California Petroleum Company in that year. The California Petroleum Company was subsequently acquired by The Texas Company in 1928. Until 1940, the refinery was owned or operated by the International Refining Company as a subsidiary of The Texas Company. In 1940, the refinery was renamed the Sunburst Works of the Texas Company. The Texas Company (which subsequently changed its corporate name to Texaco in 1959) continued to acquire additional land at the site through approximately 1951.

During refining operations, the principal product produced at the former refinery was gasoline of various grades. Other products included #6 fuel oil, diesel fuel, and minor amounts of kerosene. Refined products were produced by fractional distillation. A railcar loading/off-loading rack was oriented north-south, parallel to the BNSF railroad. The loading rack was used to unload raw materials and additives from railcars and to load products onto railcars for shipment. The infrastructure associated with the loading rack generally consisted of pumping equipment, conveyance piping, and a rail siding. A second railcar loading/off-loading rack was located to the south, outside of the former Texaco refinery property. That loading rack was located at the east boundary of the Snow Cap refinery, adjacent to the railroad. In reviewing historical aerial photographs, it appears the northern most portion of the Snow Cap railroad loading racks extend partially onto the former Texaco refinery property. Both railcar loading racks are included within the Facility boundary.

Refinery wastes and by-products were disposed of and contained using several different methods. Spills and leaks from the storage tank area were partially confined in bermed areas around each tank, but may have migrated into areas outside of the tank berms. Equipment, tanks, and concrete surfaces in the distillation area were routinely cleaned by a water washing process. The wastewater and oil were routed through an oil trap located at the southeast corner of the process area. The oil trap skimmed petroleum products from the water for recycling or incineration. The resulting wastewater was channeled to wastewater lagoons east of the BNSF railroad. General office waste and debris were disposed of at the local municipal landfill.

By 1957, the refinery had a reported daily operating capacity of 8,000 barrels. At that time, The Texas Company announced plans to close the refinery. Closure of the refinery was postponed, however, and it continued to operate intermittently until 1961. In 1961, the plant was shut down, and the former refinery property was sold to Pacific Hide and Fur, Inc. (PH&F).

After 1961, Texaco owned no interest in the former refinery. PH&F subsequently demolished and salvaged most of the refinery facilities, including distillation and processing equipment and above-ground storage tanks. The demolished equipment was removed from the site and sold or scrapped. In 1967, PH&F sold the property to Creed Davis (deceased). After 1967, Creed Davis sold several portions of the property to other individuals.

Texaco, Inc. combined with Chevron Corporation on October 9, 2001, to form ChevronTexaco Corporation. In 2005, ChevronTexaco officially changed its name to Chevron Corporation. Texaco Inc. is currently a Delaware Corporation and a wholly owned subsidiary of Chevron Corporation. Chevron Environmental Management Company (CEMC, a subsidiary of Chevron Corporation) is appointed as the attorney-in-fact for Texaco Inc., for managing environmental investigation and remediation activities. Since 2005, CEMC has purchased portions of the former refinery property that had been previously sold to individuals by Creed Davis, as well as some additional adjacent acreage.

The former refinery is divided into the following general areas: tank farm, refining operations and production (hereinafter referred to as the process area or former process area), cooling water reservoir, and wastewater treatment area. These areas are shown on Figure 1.2-2 and discussed in more detail in Section 1.2.3. Current property ownership and the location of other features are also depicted on Figure 1.2-2.

1.2.3 CURRENT REFINERY PROPERTY DESCRIPTION

The current physical structures located within the original footprint of the former refinery property are comprised of two stabilized waste landfills, one construction/demolition debris landfill, and a number of buildings. The buildings include office and storage buildings utilized by CEMC and contractor personnel, four residences and associated outbuildings, and a church. One of the four residences served as housing for refinery personnel during its operating period. The remaining three residences were constructed following refinery closure, and division and sale of the property by Creed Davis. Two of those residences, currently occupied, are located at the north end of the former refinery property in an area that never contained refinery infrastructure. The third residence, currently unoccupied, was constructed within a former tank berm area.

The former refinery is divided into the following general areas: tank farm, process area, cooling water reservoir, railcar loading racks, and wastewater treatment area. These areas are shown on Figure 1.2-2. As noted in the previous section, CEMC has reacquired a number of the properties that had been sold to individuals following refinery closure. Current property ownership and the location of other features are also depicted on the figure. Figure 1.2-3 depicts historical buildings and structures associated with the former refinery operations.

Each of these general areas is briefly described below. Detailed information and figures can also be found in the submittals entitled *Subsurface Investigation Report, Indoor Ambient Air Sampling Program, and Human Health Risk Assessments, Former Texaco Sunburst Works Refinery* (May 31, 2001) and *Voluntary Cleanup Plan, Former Texaco Sunburst Works Refinery* (March 19, 1999).

Former Tank Farm Area – The tank farm covers most of the former refinery and was located south and west of the former refinery process area. A total of 40 tanks berms have been identified as being associated with the former refinery, at various times in its operating history. Based on a review of available aerial photographs, information from former refinery employees, and CEMC field reconnaissance of existing tank berms, which revealed the presence of metal rivets and other scrap metal, it is believed that all tanks berms at the former refinery site had at one point in time contained an above-ground storage tank (AST). Five of the 40 tank berms, located to the northwest and designated as Tank Berm 35 through Tank Berm 39, were occupied by above ground product/process storage tanks that were dismantled and removed prior to 1951. Four of the five tanks were dismantled and removed prior to 1937; the fifth tank was removed between 1937 and 1951. Two water storage tanks owned by the Town of Sunburst are located near the north end of the former refinery.

Former Process Area – The process area was on the east side of former refinery, immediately west of the BNSF railroad tracks and the county road. Former major physical-plant facilities located in the process area included ASTs, tetraethyl lead storage and blending facilities, distillation towers, and a polymerization unit. All concrete foundations and support structures of the processing units, towers, and tanks have been dismantled and removed from the site.

Former Cooling Water Reservoir – A U-shaped cooling water reservoir was located north of the process area. The cooling water reservoir was 13 to 15 feet deep and encompassed approximately 2.5 acres of the former refinery property. Petroleum residue (i.e., sludge) and petroleum impacted soils were removed from the cooling water reservoir during activities conducted in accordance with the Facility's Voluntary Cleanup Plan (VCP). Cleanup levels or preliminary remediation goals (PRGs) used during the VCP are discussed at the end of this section. The reservoir was subsequently used as a repository for construction and demolition debris (e.g., concrete, brick, wood, and scrap metal) from the former refinery site.

Former Railcar Loading Racks – A railcar loading/off-loading rack ("loading rack") was located east of the Texaco refinery process area, between the county road and the BNSF railroad tracks. Oriented north-south and parallel to the railroad, the loading rack was approximately 1,629 feet long. It was used to unload raw materials and additives from railcars, and to load products onto railcars for shipment. The infrastructure associated with the loading rack generally consisted of pumping equipment, conveyance piping, and a rail siding. Infrastructure remaining after the scrapping of

the refinery in the 1960s was removed during VCP activities, and soil was excavated from an area at the north end of the loading rack. The excavation area extended approximately 525 feet north-south and 10 feet east-west.

A second railcar loading/off-loading rack, associated with the former Snow Cap refinery, was located to the south of the former Texaco refinery property. Based on review of an aerial photograph from 1961, that loading rack was approximately 800 feet long and located at the east boundary of the Snow Cap refinery, adjacent to the railroad.

Former Wastewater Treatment Area – The former wastewater treatment area is bermed and covers approximately 31 acres, and is located east of the Burlington Northern Railroad tracks and county road adjacent to an unnamed intermittent lake. Three smaller surface impoundments, designated Lagoon 1, Lagoon 2, and Pit 1, were located at the southwest corner of the wastewater treatment area. During refinery operations, wastewater was routed through an oil trap located near the southeast corner of the process area. The trap skimmed petroleum products from the water for recycling or incineration. The resulting wastewater was then channeled to the wastewater lagoons east of the railroad tracks. Two lagoons were connected by a waterdraw whereby the lighter floating petroleum products were skimmed from one lagoon and incinerated in a small brick kiln located adjacent to the lagoons, and the water flowed into the other lagoon through the waterdraw for evaporation. Petroleum products were skimmed from Lagoon 2, collected, and recycled or incinerated in a small brick kiln which was located adjacent to Lagoon 1.

During the VCP, approximately 16,000 cubic yards of material was excavated from the wastewater treatment lagoons. Excavated materials were stabilized and grab samples were collected to demonstrate stabilization procedures were effective in reducing leachable concentrations of constituents. Stabilized material was analyzed for benzene, total lead and total petroleum hydrocarbons (TPH). For benzene and total lead analyses, analytical results were compared to the federal toxicity characteristic leaching procedure (TCLP) limits of 0.5 milligrams per liter (mg/L) and 5.0 mg/L, respectively.

Following excavation, 23 soil samples were collected from beneath the excavation (depths ranging from 2 ft-bgs to 10 ft-bgs) and submitted for laboratory analysis of benzene and total lead. Analytical results were evaluated against the Facility-specific PRGs developed for the VCP. All of the reported results were below the PRGs developed for the former wastewater treatment area. The process and assumptions used for developing the PRGs, as well as a comparison to currently used screening levels, are discussed at the end of this section.

Stabilized Landfills – Three landfills are present on the former refinery property. The landfills were constructed as part of the activities conducted in accordance with the VCP for the Facility (see detailed discussion in Section 1.4). The VCP included procedures for the excavation and consolidation of sludges and impacted soils from various

locations around the former refinery property. The sludges and impacted soils were stabilized with cement kiln dust (CKD) and consolidated into two stabilized earth landfills (referred to as the “Main Cell” and the “Lagoon Cell”). Infiltration of precipitation into these two landfills is controlled by very low permeability geosynthetic clay liners (GCLs). The GCL was placed over the 6 inches of clean fill and subsequently covered with 14 inches of clean soil and topsoil.

A third landfill was created in the former cooling tower basin for placement of non-transmission piping, concrete rubble, and building demolition debris. This landfill, referred to as the “Construction/Demolition Debris” Landfill, is covered with three feet of clean fill (an evapotranspirative cap) and four inches of topsoil. The topsoil on all three landfills was seeded with native grasses and mulched to establish protective vegetative covers. All landfills are fenced and signed.

As stated in the general area summaries above, Facility-specific PRGs were developed for VCP activities, based on preliminary remedial action objectives (PRAOs). MSE-HKM, Inc. of Butte, Montana prepared for MDEQ the Public Review Draft PRAOs and PRGs for the former refinery in a report dated June 1996 (*Preliminary Remedial Action Objectives and Preliminary Remediation Goals for the Texaco, Inc. Sunburst Works Refinery, Sunburst, Montana*). This report is presented as Appendix I of the March 1999 VCP. The report established medium-specific PRAOs, which served as guidelines in the development of PRGs, and development and evaluation of remedial alternatives.

The PRGs were used to define cleanup levels for the contaminants of concern considered most important for developing remedial alternatives, and to verify that the horizontal and vertical extent of contaminated soils at the site had been adequately addressed.

The table below presents the PRGs for soils during the VCP.

Constituent of Concern	Cleanup Goals (mg/kg)	Notes
Benzo(a)pyrene Toxicity	20	Represents the sum concentration of B2 (probable human carcinogenic) PAHs found on the USEPAs Priority Pollutant List.
Total Lead	500	
Total Petroleum Hydrocarbons	11,600 for 0-2 ft-bgs; 28,000 for >2 ft-bgs	

In a letter dated October 15, 2010, MDEQ required that CEMC complete additional soil sampling surrounding and beneath all soil excavations conducted as part of the VCP to determine whether soils exceeding current MDEQ soil screening levels for constituents of interest (COIs) are present in those areas. The soil screening levels for those COIs used during the VCP, to verify that the horizontal and vertical extent of contaminated soils at the site were adequately addressed, were significantly higher than the current screening levels used by MDEQ. For benzo(a)pyrene, the current screening level (direct contact, residential) for subsurface soil is 5 milligrams per kilogram (mg/kg); for lead, 400 mg/kg; and for TPH, 500 mg/kg (lowest value of the various fractions).

1.3 FACILITY SETTING, PHYSICAL CHARACTERISTICS, NATURAL FEATURES

The Sunburst area is located in the glaciated Missouri Plateau of the Great Plains physiographic province. The area east of Sunburst consists of rolling plains of gentle relief that contain undrained depressions forming numerous alkali lakes and flats. An escarpment approximately 200 feet high marks the outcrop of the Virgelle Sandstone Member of the Eagle Formation west of Sunburst. Melt water from glaciers has cut steep ravines into the Virgelle escarpment and formed step-like terraces cut by small streams. Drainage in the area is poorly developed, resulting in numerous small, undrained depressions. The Sunburst area is drained by small, ephemeral streams that flow into intermittent lakes.

The former refinery is located in a glacial outwash channel extending from a point near the Town of Sweetgrass, Montana, southward through the towns of Sunburst and Kevin, Montana. The western part of the property lies on a topographic high sloping to the northeast and east. The eastern part adjoins an unnamed intermittent lake (see Section 1.3.3 for more information). Elevation varies from approximately 3,470 feet above mean sea level (ft-amsl) along the western boundary to about 3,320 ft-amsl in the lake bed. The ground surface at the former refinery generally slopes downward to the northeast and east with a typical grade of 3 percent in the western part and 6 percent in the eastern part. Steeper grades are locally present at the former refinery, along some surface drainages and tank berms. The lake bed is flat with a slope of 0.3 percent.

The topography has been changed by fills and excavations during refinery operations, actions by individuals following refinery closure and subsequent property sale, and prior remedial actions taken at the former refinery (see Section 1.4 and Appendix 1-B). The most obvious topographic modifications are the stabilized waste landfills and the remaining tank berms. The tank berms are up to approximately 20 feet high on the down-slope sides decreasing in height to less than 5 feet on the up-slope edges. The landfills range from approximately 5 to 20 feet above grade.

The local climate is semi-arid as reflected in the poorly established drainage system and lack of perennial streams. Precipitation in the form of rain and snow is the primary source of water that sustains dry-land agriculture. Average

annual precipitation in the area is approximately 12 inches with about 50 percent occurring during the months of May, June, and July (based on 55 years of data recorded at the weather monitoring station located nearest to Sunburst [Station “Sunburst 8E, #247996], National Climatic Data Center Cooperative Stations, part of the National Oceanic and Atmospheric Administration). Precipitation amounts can vary greatly from year to year. The mean annual snowfall is approximately 29 inches. The mean annual temperature is approximately 44 degrees Fahrenheit (°F), ranging from a mean monthly temperature of 66°F in July to 22°F in January.

1.3.1 AREA GEOLOGY/HYDROGEOLOGY

The Sunburst area lies on the east flank of the Sweetgrass Arch (locally called the Kevin-Sunburst Dome) in the Missouri Plateau of the Great Plains (Zimmerman 1967). The sedimentary rocks that underlie the region form a northwest-southeast trending arch. Upper Cretaceous sedimentary units that outcrop in the area are (from oldest to youngest): the Kevin Member of the Marias River Shale (Colorado Group shale), the Telegraph Creek Formation, and the Virgelle Member of the Eagle Sandstone. The uppermost bedrock formation below the former refinery is the Kevin member of the Marias River Shale (Colorado Group). The Kevin Member of the Marias River Shale outcrops in the Sunburst area and consists of dark gray marine shale with some thin sandy partings. Numerous thin layers of bentonite and sandy limestone beds up to 0.25 centimeters (cm) thick are also found in the Kevin Member (Cobban et al. 1976). Beds of calcareous concretions weathering gray, yellow, or red are present throughout the member. The Kevin Member is approximately 600 feet thick at Sunburst and thickens to the west.

The Marias River Shale is underlain by the Blackleaf Formation (Colorado Group) which consists of dark gray marine shales and carbonates. The combined maximum thickness of these two formations of the Colorado Group is over 1,000 feet. Most of the bedrock in the area is blanketed by 2 to 30 feet of Quaternary glacial drift or alluvium. Glacial drift occurs as outwash channels and glacial lake deposits consisting of gravel, sand, and till. The alluvial deposits consist of clay, silt, and sand with some gravel lenses.

The principal aquifers in the region are, in descending order, Quaternary deposits, the Cretaceous Two Medicine Formation and Virgelle Sandstone, and the Mississippian Madison Group. The water-bearing characteristics of the Quaternary deposits vary greatly depending on their sorting, stratification, and lateral extent. The Two Medicine Formation and the Virgelle Sandstone crop out west of the Facility, and do not underlie the Facility. The Marias River Shale, including the Kevin Shale, underlies the Facility and is not a significant water-bearing unit. The Mississippian Madison Formation is at a depth greater than 1,000 feet at the Facility.

Groundwater supplies in the Sunburst area are limited. Groundwater availability in the Quaternary alluvial deposits in the Sunburst area generally occurs in discontinuous, isolated lenses of silt, silty sands, and silty-clayey gravel-sand mixtures located at the contact with the weathered shale. An historical review of the Montana Bureau of Mines and Geology water-well records identified four wells within two miles of Sunburst. Three wells installed within the Quaternary deposits to a maximum depth of 15 feet are located in Section 21, T36N, R2W, approximately 1.5 to 2 miles southeast of the former refinery. The wells are completed at an elevation equal to or higher than groundwater elevations at the Facility. The groundwater-flow direction in this area is to the northwest, towards the Facility. A fourth well is located in Section 16, T36N, R2W, approximately 1 to 1.5 mile east of the former refinery. This well was drilled to 123 ft-bgs and completed in the Kevin Shale.

The wells described above were installed in 1930 or earlier. Reported yields from these wells range from 1 to 30 gallons per minute (gpm). Water use from these wells is recorded as irrigation and stock; current water use is unknown. Although groundwater-quality data from these wells are not available, the water probably contains high concentrations of dissolved solids and salts, including magnesium, sodium, and sulfate (Miller 1989). The underlying bedrock consists of marine shale (Kevin member of the Marias Shale) which usually produces groundwater high in total dissolved solids (TDS). Also, there are several locations on the Sunburst 7.5 minute quadrangle sheet that are referred to as alkali, suggesting that the area may have high TDS groundwater.

Due to the high TDS content, high natural specific conductance and poor yield, the shallow groundwater beneath Sunburst is not used for any personal or commercial purposes, and does not have the potential to be used as a drinking water. The Montana Water Quality Act provides for water quality protection in the State, which is based on established classifications for all state waters, and standards that are applied to state waters based on classification. Classes of groundwater are defined in the *Administrative Rules of Montana* (ARM), Chapter 30, Subchapter 10, Rule 17.30.1006, Section (4), with specific conductance providing the primary basis for classification. Groundwater quality at and near the Facility has been monitored since 1990, with substantial additions of wells since 2000 and most recently during the Phase II RI investigation.

Specific conductance data collected between 1990 and 2011 for the groundwater present beneath the Facility and the Town of Sunburst were evaluated from multiple perspectives to determine its classification. Statistical analyses performed as part of the evaluation indicate the groundwater (both on and off-Facility) meets the Class IV criterion in nearly 90 percent (%) of the sample set. The mean specific conductance has been measured above the Class IV groundwater criterion of 15,000 $\mu\text{S}/\text{cm}$ in every quarter for the past five years and has not changed with sample size, seasonality or slight changes to sample methods. Furthermore, the specific conductance is consistent and above the Class IV groundwater criteria for all lithology types, regardless of whether the well has been impacted by hydrocarbon

from the former refinery. Based on the results of these statistical and spatial analyses, presented in detail in Appendix 1-C, groundwater at and near the Facility meets the definition of a Class IV groundwater provided in the ARM, Chapter 30, Subchapter 10, Rule 17.30.1006. Groundwater classification has an impact on the data evaluation process and in development of a CSM for the Facility, the significance of which is discussed further in subsequent chapters of this document.

Shallow groundwater in the area around Sunburst generally occurs at approximately 5 to 35 ft-bgs in the unconsolidated sediments and weathered Marias River Shale. The thickness of overburden sediments varies from approximately 10 to 50 feet over most of the Facility. In the lakebed east of the Facility, the thickness of sediments may be greater than 100 feet. The unconsolidated materials primarily consist of clayey silt and silty clay with occasional lenses of silty fine sand. The shallow water-bearing zones typically occur in the coarser grained materials within the alluvial sediments, and are confined by low-permeability clays. Recharge to these zones occurs from precipitation infiltration and runoff at the Facility. Shallow groundwater generally flows from areas of higher elevation in the southwest portion of the Facility north and/or east toward lower elevations. Shallow groundwater gradients range from a relatively flat area (>1 percent) northwest of Tank Berm 34 to 6.5 percent in the portion of town near the high school.

The Two Medicine Formation is a water table (unconfined) aquifer with well yields of 10 gpm or less. The formation is present 10 miles west of Sunburst and consists of green to gray mudstone, siltstone, and sandstone. The aquifer is hydraulically connected to the Virgelle Sandstone in places and produces water similar in quality to that of the underlying Virgelle.

The Virgelle Sandstone exists under both water table and confined conditions and is the principal aquifer in the region, supplying water to the towns of Sunburst, Kevin, and Cut Bank. The Virgelle Sandstone outcrops four miles west of Sunburst and increases in depth in a westerly direction. The Virgelle Sandstone aquifer does not underlie the Facility. The Virgelle is a gray to buff sandstone and shale with water yields of up to 250 gpm at 75 to 225 ft-bgs.

Transmissivity ranges from 700 to 50,000 gallons per day per foot (gpd-ft), depending on the location and extent of fracturing (Zimmerman 1967). Water quality in the Virgelle varies, with TDS concentrations ranging from 500 to 5,000 parts per million (ppm). Sunburst obtains its water from wells located approximately 14 miles west of town that are completed in the Virgelle. A groundwater divide in the Virgelle Sandstone trends in an east-west direction along the north boundary of T35N in Ranges 4 and 5 West southwest of the Facility. Water moves to the southwest and north from this divide under a hydraulic gradient of approximately 50 feet per mile. Aquifer recharge is from infiltration at outcrop areas and leakage from other aquifers. Discharge is primarily from pumping wells.

The Kevin member of the Marias River Shale crops out west of the Facility and consists predominantly of shale with a few thin shaly sandstone beds. The Kevin member is not considered a significant water-bearing unit. Water depth ranges from 20 to 40 ft-bgs, but may be as deep as 50 ft-bgs. Water levels vary seasonally by 5 to 20 feet, with the highest levels occurring in May, June, and July during the periods of maximum precipitation (Miller 1989). Water produced from the unit is poor in quality with high concentrations of sodium, magnesium, and nitrates. TDS concentrations vary from 5,000 to 60,000 ppm (Miller 1989). Recharge occurs from precipitation infiltration and runoff from higher elevations. Groundwater flow is to the north and east under a gradient estimated to range from 1.5 percent to 5 percent. Discharge occurs from a limited number of wells used for stock-watering purposes and natural discharge near the unnamed lake east of Sunburst.

The Madison Group is a confined aquifer at 1,000 to 1,500 ft-bgs consisting of crystalline limestone and shale. The aquifer has both fracture and cavernous porosity which varies over short distances, causing a wide range in hydraulic properties. Zimmerman (1967) reported that specific capacity may range from 0.415 to 4.034 gallons per minute per foot (gpm/ft) and transmissivity may range from 600 to 6,500 gpd-ft. Wells completed in the Madison may have yields of up to 500 gpm, with TDS concentrations of up to 7,000 ppm (Zimmerman 1967). Produced water is unsuitable for domestic or agricultural purposes, but may have limited industrial applications.

1.3.2 AREA SURFACE WATER, SEDIMENTS, SOILS

The Sunburst area is located in the Missouri River drainage basin. The area south of Sunburst is drained by tributaries to the Marias River. The area north of Sunburst is drained by tributaries to the Red River, which flows north into Alberta, Canada, where it joins the Milk River. Drainages near the Facility include Buckley Coulee, Wolf Coulee, and an unnamed intermittent lake. The unnamed lake is just to the east of the former refinery and periodically contains water (i.e., after heavy precipitation events). No domestic, industrial, or agricultural users of the lake water have been observed. During refining operations treated wastewater was discharged into the refinery's bermed evaporation pond, also referred to as the former wastewater treatment area. A review of historical aerial photographs indicate direct communication occurred between the intermittent lake and the bermed evaporation pond, via a culvert, most notably during periods of high water likely resulting from heavy precipitation. The Town of Sunburst discharges its treated wastewater sewage into the lake bed. The lake is used by waterfowl on the limited basis that water is present. There are no permanent surface water bodies on or near the Facility, with the exception of the Town of Sunburst's municipal sewage lagoons, which are located approximately 2,000 feet southeast of the former refinery property and cover approximately 10 acres. The general overland flow pattern is to the northeast and east.

Surface water and associated sediments are contained in the unnamed lake east of the refinery and in drainage ditches flowing east, north and south of the former refinery property. Bottom sediments in the lake consist of grayish-brown silty clay. Sediments in the drainage ditches generally consist of brownish-gray silty clay.

In July 2011, a wetland and stream assessment was performed at the Facility, which included the former wastewater treatment area within the eastern portion of the former refinery property. The former wastewater treatment area was found to be bermed, covers approximately 38 acres, and is located east of the BNSF tracks, adjacent to the unnamed intermittent lake. As part of the Phase II RI, areas within the former railcar loading area and the former wastewater lagoons were investigated to define the nature, degree, and extent of refinery-related environmental impacts.

Riparian wetlands surrounding the unnamed intermittent lake and two drainage features were observed during the July 2011 site visit. Emergent freshwater wetlands were observed along the majority of the perimeter of the intermittent lake to the east. These wetlands appeared to have developed due to the fluctuation of water within the reservoir over time. The presence of hydric soils, wetland hydrology and hydrophytic vegetation, indicates that these areas are considered functional wetlands.

Two unnamed drainage features were also documented in the northwestern portion of the Facility. The upper reach of one of the drainages appears to be spring fed, with flowing water present during the site visit, but loses the groundwater influence as the channel continues to the northeast. The second unnamed drainage consists of a channelized system within the upper and lower reaches, with a small basin caused by a man-made impoundment in the central section of this drainage feature. The channelized portion of this feature terminates in the northern portion of the property, resulting in overland sheet flow.

The wetlands and stream assessment identified three potentially jurisdictional features in association with the property. A request for a jurisdictional determination (JD) was prepared for submittal to the United States Army Corps of Engineers (USACE) in August 2012. The USACE was contacted in May 2013 to determine the status of their review, at which time it was reported the USACE had no record of the JD request. At the direction of the USACE, CEMC utilized the information developed in August 2012 to submit a JD request, submitted on July 29, 2013 (Appendix 1-D). Final authority for jurisdiction determinations rests with the Montana Regulatory Office, Omaha District, USACE office, located in Billings, Montana. By letter dated October 21, 2013, the USACE indicated these areas are not jurisdictional waters of the United States under the authority of the Clean Water Act. A copy of that approval letter is included in Appendix 1-D.

Soil types for the general area were obtained from unpublished data prepared by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) in Shelby, Montana (Johnson 1989). All of the data and corresponding maps are subject to verification and change by the Shelby Soil Survey Office. Although the soil survey covers the area surrounding the Facility, the former refinery property itself has not yet been mapped. Local soils are associated with the old Milk Creek drainage. According to the SCS, Sunburst area soils derived from alluvium generally have a clayey texture and contain abundant salts.

Sunburst area soil types vary depending on topographic position and proximity to drainage systems. Area soils generally consist of the Joplin and Hillon Series. Joplin Series soils are up to 60 inches thick, well-drained, and moderately permeable. The upper 40 percent of the soil is grayish brown, friable, fine-grained, and contains up to 25 percent pebbles. At depths of 2 ft-bgs or greater, Joplin Series soils become blocky in structure and contain lime concretions and locally abundant gypsum crystals. Soil pH is 7.8 at the surface and increases to 8.0 at approximately 2 ft-bgs.

In the drainage areas, the soils consist of the Hillon Series. These soils are grayish brown to dark grayish brown, sticky, strongly effervescent, and moderately alkaline. The soil may contain up to 35 percent clay, which contributes to the low permeability and rapid runoff at some localities.

1.3.3 AREA ECOLOGY

The Facility lies in a semi-arid area on the Missouri Plateau of the Great Plains. This area is characterized by rolling plains of gentle relief with poor drainage and a lack of perennial streams. The topography varies, with slopes ranging from 0% to approximately 30%. The western side of the Facility has slopes between five and 30%. The central part of the Facility has slopes ranging from 0-15%. The native mixed-grass prairie ecosystem consists of natural grasslands dominated by western wheatgrass (*Pascopyrum smithii*), and needle and threadgrass (*Hesperostipa comata*). Other species include: crested wheatgrass (*Agropyron cristatum*), Kentucky bluegrass (*Poa pratense*), thistle (*Cirsium spp.*), Indian ricegrass (*Achnatherum hymenoides*), alkali sacaton (*Sporobolus airoides*) and alkali cordgrass (*Spartina gracilis*). The area immediately surrounding the Facility contains a diverse mix of plant species. Percent ground cover varies between 0 and approximately 90%, with shrub and tree species interspersed throughout the grassland communities. Some of the shrubs and trees that exist in this area include: greasewood (*Sarcobatus vermiculatus*), Wood's rose (*Rosa woodsii*), Garder's saltbush (*Atriplex gardneri*), Russian olive (*Elaeagnus angustifolia*), and cottonwood (*Populus spp.*).

Alkali lakes and flats are formed in natural depressions. There are several small, intermittent lakes or playas near the Facility, including a large, flat playa basin located immediately to the east of the former refinery's wastewater treatment area. Surface water is present within the playa basin during/after periods of adequate precipitation and/or wastewater discharge (typically occurs in the spring and fall). In this document, that playa basin is typically referred to as the "unnamed intermittent lake" or "intermittent lake to the east".

These lakes and playas may be used by migratory waterfowl for breeding, nesting, and staging. The United States Fish and Wildlife Service (USFWS) manages six waterfowl management areas in the Sunburst vicinity, ranging in size from 80 to 900 acres. Waterfowl populations vary from year to year as well as seasonally due to fluctuations in surface water. The unnamed intermittent lake provides suitable habitat for shorebirds, such as sandpipers and plovers. However, lake use by ducks and other waterfowl is low as a result of seasonally fluctuating surface water and lack of standing water.

There are a number of bird species that utilize the areas adjacent to the Facility. The type of species varies with the specific habitat and vegetation community. Some of the species that use this area are the Western meadowlark (*Sturnella neglecta*), red-tailed hawk (*Buteo jamaicensis*), sparrow (*Passer spp.*), mourning dove (*Zenaida macroura*), American robin (*Turdus migratorius*), loggerhead shrike (*Lanius ludovicianus*), killdeer (*Charadrius vociferus*), brown-headed cowbird (*Molothrus ater*), Brewer's blackbird (*Euphagus cyanocephalus*), magpie (*Pica pica*), Swainson's hawk (*Buteo swainsoni*), horned lark (*Eremophila alpestris*), ferruginous hawk (*Buteo regalis*), and red-tailed hawk (*Buteo jamaicensis*). The areas surrounding the lakes and playas provide habitat for other species, including: the American avocet (*Recurvirostra americana*), California gull (*Larus californicus*), yellowheaded blackbird (*Xanthocephalus xanthocephalus*), Canada goose (*Branta Canadensis*), and Mallard duck (*Anas platyrhynchos*). Ground birds in the area include the sharptailed grouse (*Tympanuchus phasianellus*), pheasant (*Phasianus colchicus*), and Hungarian partridge (*Perdix perdix*).

Large mammals native to the area include mule deer (*Odocoileus hemionus*), antelope (*Antilocapra americana*), and whitetail deer (*Odocoileus virginianus*). Smaller mammals include ground squirrels (*Spermophilus spp.*), white-tailed prairie dogs (*Cynomys leucurus*), long-tailed weasels (*Mustela frenata*), blacktailed jack rabbits (*Lepus californicus*), red foxes (*Vulpes vulpes*), coyotes (*Canis latrans*), and kangaroo rats (*Dipodomys deserti*).

According to the USFWS and Montana Department of Fish, Wildlife, and Parks (FWP), there is one threatened or endangered species and one candidate species that occur in Toole County, Montana:

Black-footed ferret (*Mustela nigripes*): According to the USFWS and the FWP, this mammal is currently listed as “endangered” in Montana (MFWP 2012, USFWS 2012). The black-footed ferret can be found almost exclusively in and around prairie dog (*Cynomys spp.*) colonies. The black-footed ferret is dependent on prairie dogs for food and they also use prairie dog burrows for shelter, parturition, and raising young. Although this species has not been observed at the Facility, its presence is possible due to the number of active prairie dog colonies.

Sprague’s Pipit (*Anthus spragueii*): According to the USFWS and the FWP, this bird is currently listed as a “candidate” in Montana (MFWP 2012, USFWS 2012). The Sprague’s Pipit is a small passerine bird endemic to the North American grasslands. The Pipit can be found in dry areas in open grassland with no shrubs. Sprague’s Pipit is dependent on arthropods and vegetable matter for food (Robbins and Dale 1999). Although this species has not been observed at the Facility, its presence is possible due to the presence of suitable prairie habitat near the Facility.

1.3.4 NEARBY REGULATED SITES/FACILITIES

CEMC has performed several reviews of MDEQ Remediation Division data to assess what regulated sites may be near the Facility. The reviews consisted of searching for information regarding underground storage tanks (USTs), petroleum releases, and release compensation sites via Montana’s Natural Resource Information System (NRIS) Geographic Information System website (<http://nris.state.mt.us/gis/default.htm>), as well as physical review of records available within MDEQ’s Helena office. The most recent review was conducted in May 2012.

Based on the reviews conducted, there are no Water Quality Act or MDEQ Enforcement Division spills within 1/4 mile of the Facility. However, there are five documented petroleum release sites in the Town of Sunburst:

- MDEQ Facility ID Number 51-01073, Release #3061 combined with #3067 (Note: the NRIS database only references Release #3061, although the MDEQ files reviewed reference two releases that were combined).
- MDEQ Facility ID Number 51-01378, Release #3066.
- MDEQ Facility ID Number 51-02025, Release #3242.
- MDEQ Facility ID Number 51-02025, Release #3797.
- MDEQ Facility ID Number 60-15132, Release #4378.

These five releases occurred at four distinct property locations, which are shown on Figure 1.2-2. The petroleum releases are located within the Town of Sunburst, approximately 1,200 feet to 2,400 feet (0.23-0.45 miles) from the Facility. MDEQ files were reviewed in April 2012 to determine the current status of these releases. The results of the review for each release are summarized in the following paragraphs.

Facility IDs 51-01073 and 51-01378. These facilities have had several petroleum releases, as documented by MDEQ records. MDEQ UST notification documents identified the owner in 1984 as North Country Co-op, with ownership transferred to Suta's Supply in 1990. Two initial releases were reported for Suta's Supply in November 1996 for the northern portion of the property, north of 1st Street North, identified as Release ID #3061 and Release ID #3067 (Facility ID 51-01073). A third release was also identified for the southern portion of Suta's Supply (south of 1st Street North) in November 1996 and is identified as MDEQ release ID #3066 (Facility ID 51-01378). A remedial investigation was performed for both facilities in 2000 under the direction of MDEQ. Investigation results indicated soil was impacted with a number of constituents, including benzene, toluene, ethylbenzene, naphthalene, C9-C10 aromatics, C5-C8 aliphatics, and total extractable hydrocarbons (TEH). The groundwater results indicated the presence of benzene, ethylbenzene, C5-C8 aliphatics, C19-C12 aliphatics, and C9-C10 aromatics. The groundwater gradient was determined to be to the south at 0.0082 ft/day across the Suta Supply property, both north and south of 1st Street North.

As a follow-up, MDEQ requested additional investigation for both facilities. However, MDEQ records indicate no additional investigation was performed between 2000 and 2009. The northern portion of Suta Supply, Facility ID 51-01073, was sold in 2007. The recent review of MDEQ files suggest that no additional correspondence between MDEQ and the current or previous owner has occurred since February 2009. Regarding the southern part of Suta Supply (Facility ID 51-01378), MDEQ records contain correspondence from March 2009 in which MDEQ indicated it would "temporarily postpone the request for additional investigation for the railroad loading areas" after the owner suggested that the former Texaco Sunburst Refinery operations may have contributed to the contamination. There does not appear to be any additional correspondence since March 2009. Both releases are still listed as active and classified by the Montana Petroleum Tank Release Compensation Program as "1.4 – High Priority Characterization."

Facility ID 51-02025 has had two petroleum releases documented with MDEQ. The facility was first identified as Paul's Conoco Bulk Plant in MDEQ UST notification documents from 1986. The facility transferred ownership in 1997 and was identified as Ben/Greg Taylor Bulk Plant. Ownership was transferred to Ben Taylor, Inc., which is the current owner. An active release was reported for this facility in June 1997 during the transfer of property rights and is noted as MDEQ release ID #3242. A second release was identified for this facility in September 1999 and is identified as MDEQ release ID #3797. A Remedial Investigation Work Plan addressing both releases was submitted by Ben Taylor, Inc. to MDEQ in June 2000. The work plan was approved with comments from MDEQ in July 2000. MDEQ files reference the submittal of a Remedial Investigation Report to MDEQ in October 2001. However, the complete report could not be located at the time of the file review. CEMC has requested that document from MDEQ.

The MDEQ files indicate that no additional correspondence between MDEQ and the owner has occurred since October 2001. The Montana Petroleum Tank Release Compensation Program has classified both releases #3242 and #3797 as “1.4 – High Priority Characterization”, but it is currently assigned to the pool of fund managers and does not have a particular MDEQ release manager.

Facility ID 60-15132 is owned by the Town of Sunburst. An active release, Release ID #4738, was opened in February 2009 when two USTs were encountered during installation a new waterline for the construction of the U.S. Border Control station, located to the east of Sunburst. The USTs are located in the Town of Sunburst right-of-way on 1st Street North, adjacent to and east of the Suta’s Supply properties. The Town of Sunburst agreed to take ownership of the tanks and was permitted to remove the tanks during water line installation. At that time, soil staining was noted and subsequent sampling confirmed contamination beneath both tanks. The Town of Sunburst completed a 30-Day Release Report in August 2009. In September 2009, the Town of Sunburst contacted MDEQ to request to start work towards a remedial investigation and possible Brownfield development of the area. MDEQ files indicate that no additional correspondence between MDEQ and the owner has occurred since September 2009. The Montana Petroleum Tank Release Compensation Program has classified both releases #3242 and #3797 as “2.0 – Medium Priority Characterization”, but it is currently assigned to the pool of fund managers and does not have a particular MDEQ release manager.

As of July 2012, these five releases are still listed as “active”, according to MDEQ records. Data generated during the Phase II Remedial Investigation suggest that these releases have not contributed to Facility-related impacts.

The NRIS website does list multiple former USTs within the Town of Sunburst. Three are located within one quarter mile of the Facility:

- Facility ID 51-01309 - 500-gallon gasoline tank
- Facility ID 51-01328 - 550-gallon diesel tank and 550-gallon gasoline tank
- Facility ID 51-01376 - 1,000-gallon diesel tank and 1,000-gallon gasoline tank

The storage tanks at each of those sites have been removed. Information generated from the April-May 2012 review of MDEQ files suggest there were no releases from these tanks and the five releases discussed above are the only documented releases from UST sites.

1.4 FACILITY REGULATORY HISTORY, PRIOR INVESTIGATIONS AND REPORTING

This section provides a brief summary of the regulatory history and prior investigations conducted at the Facility, focusing on the sequence of events leading to the preparation of the Phase II RI Work Plan. A detailed history is provided in Appendix 1-B of this document.

1.4.1 DOCUMENTED RELEASES AND REGULATORY HISTORY

An explosion on July 30, 1955, in a residence north of the refinery (believed to have been caused by gasoline vapors entering the basement) and reports of gasoline on the water table resulted in Texaco conducting an investigation to determine the source of the gasoline. Texaco detected a leak in a gasoline pipeline at the refinery, and the pipeline was repaired. Texaco installed 36 hydrocarbon recovery sumps and 48 trenches during the course of its investigation and recovery efforts during 1955-1957. An estimated 4,344 barrels (182,448 gallons) of gasoline and gasoline-impacted groundwater were recovered between 1955 and 1957, at which time all but two sumps were shut down and abandoned.

A document dated September 30, 1955, generated by Texaco during its investigation of the pipeline release, indicates that a release of approximately 1,500 barrels (63,000 gallons) of crude oil occurred in “about 1951” from Tank 1072 (located approximately 2,100 feet west of the process area). The document indicates that the crude oil was not recovered. Another document, dated November 22, 1957, and generated by Texaco during its investigation of a petroleum release in Sweetgrass, Montana, indicates that “during the war, leaded gasoline was stored in our west tank farm and it may be that some of this leaded gasoline leaked into the ground.” It is assumed that the writer is describing World War II (1941-1945). No volume is provided for the possible leak. CEMC is not aware of other documented releases associated with the former refinery during its operational phase.

Texaco monitored the two recovery systems, which remained from its 1955-1957 investigation, on a quarterly basis from 1957 to 1967, and then periodically until 1973. In 1973, after 16 years of not detecting gasoline in the groundwater and with approval from the Montana Department of Health and Environmental Sciences (MDHES, predecessor to MDEQ), Texaco ended the monitoring program and abandoned the remaining sumps.

Between 1973 and 1984, no monitoring or investigative activities were conducted at the former refinery. In November 1984, the MDHES conducted a preliminary site assessment and prepared a site history report, concluding that further investigation of the site was needed. As a result of the MDHES preliminary site assessment, the United States Environmental Protection Agency (USEPA) contracted with Ecology and Environment, Inc. (E&E), to conduct a site visit in February 1985 under the Technical Directive Document (TDD) R8-8502-12, to determine if the former refinery should be included on the National Priority List. Later in 1985, USEPA contracted E&E to perform a site inspection

and sampling event under the provisions of TDD R8-8504-19. E&E performed the site inspection in June 1985 and sampled surface water, sludge, and surficial soils in July 1985 (Ecology & Environment, Inc. 1985). Results were submitted to USEPA in May 1986 providing a summary and interpretation of data collected during investigative activities (Ecology & Environment, Inc. 1986). The report provided site characterization based on visual inspection and laboratory analyses of metals in specific media. E&E concluded that while there had been a release of metals to the surface water at the site, no further action was necessary under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), because the site did not have potential to be included on the National Priority List, based on the absence of shallow groundwater and the seasonal nature of surface water at the site.

On April 25, 1989, the MDHES conducted a site inspection and presided over a meeting with residents of Sunburst to gather information on the former refinery site history. In the summer of 1989, Texaco and the State of Montana negotiated an Administrative Order on Consent for Texaco to conduct a Remedial Investigation/Feasibility Study (RI/FS) at the site. The Consent Order was signed on September 28, 1989. Investigation and remediation activities conducted since that time have been under the direction and/or with the approval of MDEQ (MDHES became MDEQ on July 1, 1995) pursuant to the Consent Order.

1.4.2 PREVIOUS INVESTIGATIONS, CHARACTERIZATION AND ACTIONS

Since finalization of the Consent Order, there have been multiple actions based on the determination the 1955 pipe leak released petroleum-related constituents to soil and groundwater beneath the former refinery. Table 1.4-1 provides a summary of investigations conducted to-date and Figure 1.4-1 provides a timeline of those investigations in conjunction with the refinery operating history. These previous investigations and their corresponding reports are summarized as follows:

Remedial Investigation, Texaco, Inc., Sunburst Works Refinery Site, Sunburst, Montana (TRC 1990b). This document details the original RI activities required by the Administrative Order on Consent. Field activities were initiated in December 1989 and completed in February 1990, and consisted of soil and groundwater sampling. The corresponding *Feasibility Study Work Plan* was submitted in 1991 (TRC 1991a), and the results of the FS are documented in the 1997 report entitled *Feasibility Study for the Former Texaco Sunburst Works Refinery Site, Sunburst, Montana (TRC 1997)*.

Residential Ambient Air Survey, Texaco Sunburst Works Refinery, Sunburst, Montana (TRC 1991b). This report documents the results of a residential ambient air survey performed in 1991. The results were used to complete a Baseline Health Risk Assessment (MSE, Inc. 1993), which, along with a recommendation from MDEQ, was the basis for a groundwater waiver request submitted to MDEQ in January 1998. MDEQ denied the request in a letter dated

June 16, 1998, citing insufficient information pertaining to the nature and extent of the petroleum contamination in the indoor air, groundwater, and soil beneath the Facility.

Voluntary Cleanup Plan, Former Texaco Sunburst Works Refinery (TRMI 1999a). The VCP focused on soil investigation activities and removal of underground piping, but did not address groundwater. Work associated with the VCP was initiated at the Facility in October 1999 and completed in 2001. On November 5, 2003, CEMC notified MDEQ that all work activities associated with the VCP had been completed, and operation and maintenance (O&M) activities initiated, per the requirements of the VCP. On March 17, 2005, MDEQ issued a letter certifying that all remedial activities required by the VCP were complete.

Subsurface Investigation Report, Indoor Ambient Air Sampling Program, and Human Health Risk Assessments, Former Texaco Sunburst Works Refinery, Sunburst, Montana (TRMI 2001a). This report presents the results of a second round of RI activities conducted between July 1999 and August 2000, in accordance with the work plan entitled Revised Work Plan to Investigate 1955 Gasoline Leak and Subsurface Impacts, Former Texaco Refinery, Sunburst, Montana, (TRMI 1999b). The work plan had been submitted in response to MDEQ comments on the initial groundwater waiver request. The resulting Subsurface Investigation Report, or “SSI Report”, was approved by MDEQ on June 19, 2001.

Feasibility Study, Former Texaco Sunburst Refinery, Sunburst, Montana (CESC 2003). The FS Report was based on the results of the SSI Report. Prior to development of the FS, CEMC performed soil vapor extraction (SVE) and multi-phase vacuum extraction (MPVE) pilot tests, and conducted groundwater monitoring to evaluate the feasibility of monitored natural attenuation (MNA) as the final remedy for the 1955 gasoline release area. Following its review of the FS Report, MDEQ proposed MNA as the preferred cleanup method for the dissolved contaminant plume present beneath portions of the Town of Sunburst.

Between October and December 2004, MDEQ contracted third-party reviews of the pilot test results and indoor air sample results conducted up to that point at the Facility. This included a review of pilot testing for SVE and MPVE technologies completed in 2004 by Water & Environmental Technologies of Butte, Montana (WET), and an additional indoor air investigation conducted by Industrial Hygiene Resources (IHR) in 2003. The pilot testing completed by WET, and the indoor air sampling investigation completed by IHR, were performed on behalf of plaintiffs in the litigation *Sunburst School District No. 2, et al. Plaintiffs, vs. Texaco, Inc.* Based upon these third-party reviews, and what MDEQ considered to be conflicting results between the various studies, MDEQ requested additional investigation work at the Facility via correspondence dated December 13, 2004.

In response, CEMC developed and submitted the following work plans to MDEQ:

- *Revised Limited Scoping Subsurface Investigation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2005a). The purpose of the Limited Scoping Subsurface Investigation (LSSI) was to assess soil and groundwater conditions at the Facility in those areas not previously assessed. The LSSI Work Plan was revised several times following receipt of MDEQ comments and ultimately approved by MDEQ on December 12, 2005. An addendum to the LSSI Work Plan was submitted to MDEQ on August 10, 2007, proposing the installation of soil borings at the Facility for purposes of investigating deeper levels of the subsurface than had previously been investigated, and conducting geophysical and hydrophysical logging at select borings to identify and evaluate discrete groundwater and contaminant flow pathways. MDEQ approved the LSSI Work Plan addendum on August 10, 2007. Results of work associated with the LSSI completed during the period of February 2006 to September 2007 were presented in a report entitled *Limited Scoping Subsurface Investigation Results, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, dated February 25, 2008 (CEMC 2008a).
- *Supplemental Investigation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst Montana* (CEMC 2005b). The purpose of the Supplemental Investigation (SI) was to evaluate the vapor intrusion (VI) pathway to indoor air of residences and other occupied structures located at or near the Facility from volatilization of petroleum hydrocarbons in groundwater, soil, or light non-aqueous phase liquid (LNAPL) originating from the former refinery. A Revised SI Work Plan was submitted to MDEQ on April 10, 2006, following several revisions based on MDEQ comments. Three subsequent addenda were submitted to supplement that work plan. The work described in the approved SI Work Plan and three addenda was conducted over a period of several years, beginning in April 2006 and ending in August 2008. Results from these efforts were reported in a document entitled *Supplemental Investigation Interim Report, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, dated October 30, 2008 (CEMC 2008d).
- *Supplemental Multi-Phase Extraction Pilot Test Work Plan* (CEMC 2005c). The purpose of this work plan was to further evaluate the effectiveness and feasibility of MPE technology for remediation of residual petroleum hydrocarbons in groundwater or on soils. Potential locations for pilot testing were identified and proposed in a revised work plan submitted July 6, 2006, and the final revised work plan was submitted to MDEQ on September 13, 2006. CEMC completed supplemental pilot testing at two locations at the Facility during late October/early November 2006. The results of the supplemental pilot testing were reported in a document entitled *Supplemental Multi-Phase Extraction Pilot Test Results, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, dated September 11, 2009 (CEMC 2009f).

Based on its review of the findings from the LSSI, SI, and supplemental pilot testing, MDEQ determined a Phase II RI was required for the Facility. As noted in the Introduction, CEMC and MDEQ met on June 3, 2009 in Helena, Montana to discuss and agree on a strategy for conducting the additional investigation activities.

During that meeting, it was agreed the CEMC would first focus efforts on collecting data necessary to further develop the Facility's CSM, and address those aspects of the Phase II RI deemed to be of higher priority (listed in Section 1.0). The CSM Work Plan was submitted to MDEQ, pursuant to those objectives, and is described below:

Data Collection Activities for Updating Conceptual Site Model, Former Texaco Sunburst Works Refinery, Sunburst, Montana (CEMC 2009e). The final work plan was submitted to MDEQ on September 4, 2009, and describes the activities to be conducted as part of the agreed strategy from the MDEQ/CEMC June 3, 2009 meeting. The CSM Work Plan also included updated lists for COIs at the Facility. The work plan originally was submitted to MDEQ in August 2009, describing the specific procedures to be used while conducting data collection/investigation activities. MDEQ approved the CSM Work Plan via email on August 20, 2009. The revised CSM Work was re-submitted to MDEQ on September 4, 2009. MDEQ subsequently issued a letter on September 22, 2009, clarifying the Agency's position on execution of certain procedures associated with the CSM Work Plan. Field activities ("CSM data collection") associated with the CSM Work Plan commenced during the week of September 8, 2009 and were completed the week of March 1, 2010.

Conceptual Site Model Update, Former Texaco Sunburst Works Refinery, Sunburst, Montana (CEMC 2010a), and Addendum to Conceptual Site Model Update, Former Texaco Sunburst Works Refinery, Sunburst, Montana, (CEMC 2010d). The CSM Update Report was submitted to MDEQ on March 1, 2010 and the CSM Update Addendum on June 1, 2010. The documents provided a summary of the activities conducted September 2009 and March 2010, in accordance with the CSM Work Plan. The large amount of analytical data generated by those investigation activities, and the time required for validation and comprehensive evaluation of those data, necessitated the submittal of two reports. The CSM Update Report summarized field activities conducted through January 29, 2010, and presented analytical results for environmental samples submitted for laboratory analysis on or before December 31, 2009. Detailed discussion of field screening data was limited to those data generated prior to January 29, 2010, again to allow time for compilation and evaluation. The CSM Update Addendum addressed investigations conducted in February and March 2010 and presented a detailed evaluation of data from environmental samples submitted for laboratory analysis after December 31, 2009, and field screening data generated after January 29, 2010. MDEQ provided CEMC with comments on the CSM Update Report and CSM Update Addendum via correspondence dated February 22, 2011 and May 2, 2011, respectively. CEMC provided responses to those comments via correspondence date August 2, 2011. Revisions to CSM-related text per MDEQ comments are included within this document.

Phase II Remedial Investigation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana (CEMC 2010f). A revision to the Phase II RI Work Plan originally submitted September 15, 2008 was submitted to MDEQ on March 1, 2010, concurrent with the submittal of the CSM Update Report. The revised Phase II RI Work Plan outlined procedures for completing investigation activities requested by MDEQ in the May 16, 2008 SOW that were not addressed by the CSM Work Plan. MDEQ provided comments on the revised Phase II RI Work Plan via correspondence dated May 14, 2010. Following a meeting with MDEQ on June 17, 2010, CEMC provided a response to MDEQ comments and resubmitted the Work Plan on June 30, 2010. MDEQ approved the Phase II RI Work Plan via correspondence dated July 8, 2010, and pending CEMC's incorporation of MDEQ comments transmitted with that letter. The Work Plan was revised as requested and submitted to MDEQ on July 22, 2010. Subsequent communications with MDEQ modified and expanded the scope of the Phase II RI and are discussed in the chapters that follow.

2.0 METHODOLOGY

This chapter provides a general summary of various methodology utilized regularly throughout completion of the Phase II RI field activities. This chapter presents the methods used during sample collection, and the procedures/methods used for data validation and data evaluation. Media and area specific information, including determination of sampling locations, sample naming convention, deviations from approved work plan procedures, specific data validation and evaluation results, etc., are discussed in corresponding chapters of this document.

2.1 FIELD SAMPLING METHODS

Following is a summary of the methods utilized to sample soil, groundwater, surface water and sediment during the course of Phase II RI. Specific details are provided in the CSM Work Plan and the Field Sampling Plan (FSP) presented in Appendix D of the Phase II RI Work Plan. Investigation methods for additional media or miscellaneous investigations (e.g., Investigation of Debris/Dump Area) are discussed in their respective sections.

2.1.1 SOIL SCREENING AND SAMPLING METHODS

Soil investigation efforts included both surface and subsurface soils, with surface defined as those soils located 0 to 2 ft-bgs and subsurface defined as soils located greater than 2 ft-bgs. Investigation methods involved a combination of field screening soil cores over various intervals and submitting samples from a percentage of the screened intervals for laboratory analysis. Portable instruments containing both a photoionization detector (PID) and flame ionization detector (FID) were used to screen for volatile organic compounds (VOCs). The PID/FID instruments were used primarily during subsurface soil investigations given that VOCs are less likely to be detected in surface soils. However, PID/FID field screening was utilized on occasion for field screening some of the “deeper” surface soil intervals.

Portable X-ray Fluorescence (XRF) units (Niton model XL3T 600 or similar) were used to field screen both surface and subsurface soils during soil investigation activities. The XRF units were programmed to screen for arsenic, barium, cadmium, chromium, lead, mercury, selenium and silver (As, Ba, Cd, Cr, Pb, Hg, Se, and Ag, respectively), with frequent and regular checks of calibration against a manufacturer-supplied standard. Standard operating and calibration procedures for use of the XRF are presented in the CSM Work Plan and the Phase II RI Work Plan FSP. Lead had been previously identified as the primary metal of interest in assessing soil impacts at the Facility. Therefore, the XRF units were programmed to display Pb readings as soils were screened.

The XRF units were used in one of two modes, either for taking in-situ measurements at the soil surface or for measuring sample material ex-situ. Because of the shallow penetration of the X-rays in typical soils, in-situ measurements were assumed, as a conservative measure, to represent 0 to 2 inches below ground surface (in-bgs). In-situ screenings were utilized frequently to determine placement of initial soil borings. Ex-situ measurements were utilized to screen soils over a vertical interval for any depths greater than 2 in-bgs, and involved placing material collected from a soil core into a plastic bag, then taking a reading through the bag. In-situ and ex-situ screening methods are described in greater detail in the CSM Work Plan and Phase II RI Work Plan FSP.

Soil cores were collected using a hand driven core sampler, Geoprobe[®], 9700 Series PowerProbe manufactured by AMS, Inc., or similar direct push device. The majority of subsurface soil investigation activities utilized the AMS PowerProbe unit. Borings were advanced to the depths specified in the CSM Work Plan, the Phase II RI Work Plan and/or the CEMC November 5, 2010, Step-Out Soil Sampling correspondence for each area of investigation. Specified boring depths are also described in Chapter 3.0 of this document. Soil cores collected generally were screened at four depth intervals (0-6 inch, 6-12 inch, 12-18 inch, and 18-24 inch) for the first 0 to 2 ft-bgs (surface soil) and at one or two foot intervals, depending upon the specified sampling program, for soils collected from depths greater than 2 ft-bgs (subsurface soil). The initial sampling program outlined in the CSM Work Plan for tank berm and tank farm sampling specified surface soils would be screened over five depth intervals (0-2 inch, 4-6 inch, 6-12 inch, 12-18 inch, and 18-24 inch). This was modified to the four depth intervals per MDEQ comments during review of the Phase II RI Work Plan.

As stated above, soil intervals were analyzed utilizing portable XRF units and PID/FID instruments. Soil intervals were placed in plastic bags. XRF readings were taken through the bag, PID/FID readings were collected from the headspace within the bag. Instrument field screening and field observations (visual impacts, odor, etc.) allowed field personnel to make real-time decisions pertaining to additional sampling locations and depth intervals collected for confirmation analysis. Samples were analyzed for the compounds on the Facility's COI list for soil (Table 2.1-1). Laboratory analyses are discussed further in Section 2.1.5.

All field activities were documented on field forms and investigation logs. Field documentation for soil investigation activities are provided in appendices associated with the area investigations presented in Chapter 3.0.

2.1.2 GROUNDWATER WELL INSTALLATION, DEVELOPMENT AND SAMPLING METHODS

This section discusses groundwater well installation and sampling methods, with emphasis placed on installation activities and the necessary adaptations to address conditions unique to the Facility.

Groundwater Well Installation

Subsurface investigation activities related to groundwater and LNAPL began in December 2009. The primary objective of the subsurface investigation was to further identify and characterize the groundwater and contaminant flow systems present at the Facility. The investigation consisted of a staged approach, which allowed information and data collected during each stage to assist in formulating the approach of subsequent stages. The first stage of investigation was completed in January 2010, and included the installation of 25 shallow and 7 deep monitoring wells. Monitoring well installation procedures during the first stage of the investigation were conducted in accordance with the procedures outlined in the CSM Work Plan. A detailed description of installation activities has been previously presented in the CSM Update and CSM Update Addendum documents.

The second stage of the groundwater investigation was conducted between September 2010 and November 2011, and consisted of the installation of 64 shallow and 38 deep monitoring wells (11 of which were deep-fracture zone monitoring wells), and 5 hydrocarbon recovery wells. Monitoring well installation during the second stage of the investigation was conducted in accordance with the procedures outlined in the Phase II RI Work Plan. The Facility's current monitoring well network is shown on Figure 4.1-1. Monitoring well borehole logs, well construction diagrams, well development forms, and groundwater sampling field forms with associated equipment calibration forms for the Phase II RI are presented in Appendices 4-A through 4-D.

The overall methodologies for drilling, sample collection, and well construction/development procedures were similar between the two stages of monitoring well installation activities. These procedures are outlined in detail in the Facility's FSP, which was presented as Appendix D in the Phase II RI Work Plan. Deviations from the FSP occurred in some instances and are discussed in Section 4.3 of this Report.

In order to present and discuss the investigation stages and the steps taken to meet the objectives, it is necessary to describe the unique and identifiable hydrostratigraphic units present at the Facility, based on the properties of groundwater flow. A hydrostratigraphic unit is defined as a body of sediment and/or rock characterized by groundwater flow that can be demonstrated to be distinct in both unstressed (natural) and stressed (pumping) conditions, and is distinguishable from flow in other hydrostratigraphic units. Gaining a better understanding of the hydrostratigraphy of the Facility allows for identification and targeting of contaminant migration pathways, delineation of individual plume geometry, and identification of the relationship between plumes and source areas. This, in turn, will assist in determining appropriate and feasible remediation strategies for the Facility.

As presented in the CSM Update Addendum document, three hydrostratigraphic units are present at the Facility. The three hydrostratigraphic units are as follows:

- Alluvial sediments
- Shallow weathered/highly fractured shale and surficial glacial sediments
- Deeper, more competent shale

Results from the second stage of monitoring well installations have led to a revised understanding of the three hydrostratigraphic units at the Facility. This is explained in detail in Section 4.5.2.1. In addition to evaluating the above hydrostratigraphic units, the second stage of monitoring well installations included the investigation of a fracture zone present in the deeper unweathered shale (varying between approximately 3,330 to 3,360 ft-amsl) which may have served as an historical LNAPL migration pathway. The drilling program began by investigating these units within the former refinery boundaries, and then expanded offsite into the Town of Sunburst. Soil/rock samples were collected continuously during drilling and inspected/described by a field geologist, and discrete samples were collected for chemical laboratory analysis based on field screening criteria described in the Phase II RI Work Plan. Continuous soil and rock samples provided a more detailed understanding of how geologic conditions vary laterally and with depth.

In reviewing results of the first stage of the Phase II RI, CEMC modified the monitoring well installation program to include two separate protocols. The two separate programs were divided into what was internally termed “Refinery” versus “Town”. The line that separates the two programs is defined as the contact in surficial sediments between glacial drift and alluvial sediments. This line is approximated on Figure 4.5-1. Monitoring wells installed to the west of this contact were termed “Refinery” wells and wells installed to the east of the contact were termed “Town” monitoring wells.

Shallow Wells: A hollow stem auger with continuous recovery was used to advance shallow well borings and characterize geologic and hydrogeologic properties of the alluvial sediments as well as the surficial glacial sediments and the upper portion of the underlying shallow weathered shale.

Shallow monitoring wells were installed differently depending on whether it fell into the “Refinery” or “Town” category. The differences between the two programs were as follows:

- Shallow “Refinery” Monitoring Wells – Shallow “Refinery” monitoring wells were screened at the first water-bearing zone if encountered above the interface of the glacial sediments and weathered shale. If no groundwater was observed during drilling and in continuous cores, wells were screened to bridge the interface between the overburden glacial sediments and weathered shale, as isolated lenses of silt, silty sands, and silty-clayey gravel-sand mixtures have often been encountered at the contact with the weathered shale. The well screens were

installed such that half the length of the screen was above the interface and half the length of screen was below the interface.

- **Shallow “Town” Monitoring Wells** – Shallow “Town” monitoring wells were screened in the alluvial sediments. Care was taken so as to not penetrate the underlying weathered shale unit. As discussed in the Phase II RI Work Plan, wells that have long screens penetrating both the alluvial sediments and weathered shale could function as a direct conduit for upwelling of impacted waters from the weathered shale into potentially clean intervals in much shallower alluvial sediments. Field personnel evaluated lithological data from proximal borings/wells to assist in estimating the depth to weathered shale.

The drilling methods used between the two areas were similar and typically produced good recovery for lithological evaluation and field screening of organic vapors, providing data for identification of both current and historical fluid (groundwater and/or hydrocarbon) migration pathways. Evidence indicating more recent fluid movement through a zone or pathway included moisture or wetness within bedding plane partings or fractures, and/or relatively high concentration total organic vapor (TOV) measurements. Evidence indicating historic fluid movement through a zone or pathway included the presence of evaporate deposits (calcite, gypsum), and iron oxide staining/precipitate deposits in bedding plane partings or fractures. Cores were examined with extreme care in order to determine as accurately as possible the depth at which first fluid was encountered. In many locations, the depth at which the first saturated interval was encountered was difficult to determine, due to the minimal amount of groundwater present in the fractures or parting planes, and the thinness (typically less than 2 inches) of the saturated interval. In addition, the heat generated by friction/rotation of the augers often resulted in a loss of most of the moisture present in the cores, adding to the challenge in interpretation.

Shallow monitoring wells were constructed using discrete screen intervals (5-foot) to isolate the zone of interest and avoid potential cross-contamination from other saturated intervals. At most boring locations, shallow monitoring wells were installed with screen at the depth where first occurrence of groundwater was identified within core samples. In some instances where there were multiple water-bearing zones present within the shallow sediments, well screen depths were adjusted based on the field geologist’s review of PID/FID field screening results, visual observations, and/or suspected areas of residual soil impacts.

Deep Wells: A combination of hollow stem auger with continuous recovery and air rotary drilling methods were used to advance deeper well borings, allowing characterization of geologic and hydrogeologic properties of the entire thickness of the shallow weathered shale and the upper portion of the deeper, more competent shale. Boreholes for deeper wells were installed at 34 locations at the former refinery and within the Town of Sunburst. At those locations



where groundwater was not observed in adjacent shallow monitoring wells, or was observed but present in very minor amounts (e.g., contained within a zone of extremely low hydraulic conductivity as demonstrated during well development), hollow stem auger with continuous core recovery was used to complete the boring to terminal depth. In those locations where groundwater was observed in greater amounts, either in adjacent shallow monitoring wells or in the boring being installed, a surface casing was installed to prevent cross communication between differing water-bearing units.

- Deep “Refinery” Monitoring Wells – Deep “Refinery” borings were advanced until competent, unweathered shale was encountered. Continuous core soil and rock samples were examined by the project geologist to determine the terminal depth of the boring. Monitoring wells were screened based on a general hierarchy as follows: Presence of hydrocarbon (LNAPL) > presence/absence of groundwater > top of competent shale > if dry use default depth. The default depth was predetermined based off lithologic and geophysical data from other proximal borings/wells that allowed an estimation of the target depth to competent shale. In general, wells were screened across the interface of the weathered shale and competent shale in order to identify the presence or absence of water-bearing zones at this contact between the units. Upon reaching terminal depth, groundwater monitoring wells were constructed using 5-foot screen length.
- Deep “Town” Monitoring Wells – Deep “Town” monitoring wells were screened into the weathered shale unit. At those deeper well locations where confined groundwater is present within the weathered shale unit, a hollow stem auger (10-inch diameter) was used to complete a boring to a depth of approximately ½ foot below the alluvial sediment and weathered shale interface. Schedule 80 polyvinyl chloride (PVC) piping (8-inch diameter) was then inserted to depth in the boring and grouted in place with a Portland cement slurry in order to seal the overlying sediments and prevent groundwater under confined conditions from flowing upward and outward into the formation through any present zones of higher permeability sediments. The Portland cement grout was allowed to cure and set a minimum of 24 hours to create a competent seal, prior to advancing the boring to depth with hollow stem auger methods. Monitoring wells were screened with the top of the well screen interval at the bottom of the surface casing. A 10/20 silica sand filter pack was placed in the annular space surrounding the screened interval to the top of the screen interval. The filter pack was not brought above the top of the well screen. A minimum of one foot of hydrated bentonite pellets/chips was placed over the sand filter pack, and a cement bentonite grout was placed in the remaining annular space to the ground surface.

Deep-Fracture Wells: Boreholes for deep-fracture wells were installed at 11 locations using the same methods as the deep borings described above. A combination of hollow stem auger and air rotary methods was used to advance the borehole to terminal depth. Borehole terminal depths were predetermined by subtracting the ground surface elevation (as determined by digital elevation data) by 3,330 feet, which coincides with the bottom of the suspected fracture zone.

The field geologist carefully examined the continuous core samples and auger cuttings to help determine whether there was evidence of groundwater. If there was no evidence of groundwater present in the fractures or parting planes, the well was screened through the entire fracture zone between 3,330 to 3,360 ft-amsl.

Similar to deep wells, if a deep-fracture well location was in an area where nearby hydraulic conditions in the upper water-bearing units might have indicated cross communication between differing water-bearing units, a surface casing was installed to seal off the upper water-bearing units. In this case, a hollow stem auger (14-inch diameter) was used to complete a boring to a depth sufficiently below the upper water-bearing units. Schedule 80 PVC piping (10-inch diameter) was then inserted to depth in the boring and grouted in place with a Portland cement slurry in order to seal off the upper water-bearing units and prevent any cross communication caused by a downward migration of groundwater. The Portland cement grout was allowed to cure and set a minimum of 24 hours to create a competent seal, prior to advancing the boring to depth with air rotary drilling methods.

Additional discussion of data collected during monitoring well installation is incorporated into the Groundwater Investigation Results and CSM chapters of this Report (Chapters 4.0 and 7.0, respectively).

Groundwater Sampling Methods

Monitoring wells installed during the Phase II RI were developed prior to initiating groundwater sampling activities. Well development procedures were designed to address the unique characteristics of the Facility and are discussed in more detail in Chapter 4.0, Section 4.3. Groundwater sampling was performed in accordance with the CSM Work Plan and Phase II RI Work Plan FSP. Groundwater samples were collected on a quarterly basis until at least four quarters of data had been collected for each well. Samples were analyzed for the compounds on the Facility's COI list for groundwater (Table 2.1-2).

Fluid level gauging, including the measurement of groundwater elevation and LNAPL elevation (if present) were recorded on a quarterly basis at each groundwater monitoring well associated with the Phase II RI. For any well where the presence of LNAPL was detected, a sample of the LNAPL was collected and submitted for forensic analyses, and that well was removed from the quarterly sampling program until LNAPL had been removed and/or was no longer observed. Wells with the presence of LNAPL were added to the routine monthly LNAPL monitoring and recovery network. LNAPL recovery is performed to the maximum extent practicable on a monthly (or more frequent) basis at all wells within the network. Details and results of sampling activities for the Phase II RI monitoring wells are included in Section 4.6 of this Report.

Groundwater samples were collected from the P2RI-prefix wells by low-flow purging and sampling techniques. At wells containing a sufficient volume of groundwater, portable submersible pumps and dedicated polyethylene tubing were used for collection of groundwater samples by low-flow purging and sampling techniques at a rate of approximately <250 milliliters per minute (ml/min). Groundwater samples from wells that had limited groundwater and/or limited groundwater recharge were collected using disposable polyethylene bailers. Water quality parameters were measured during groundwater sampling at those wells with sufficient groundwater volume present. The water quality parameters, sample date, time, physical characteristics, and other possible observations of the groundwater sample were recorded at this time (Table 4.1-3).

However, before a groundwater sample was obtained, the static water was purged from the well to ensure that a representative groundwater sample was collected. Field indicator parameters used for the stabilization criteria included turbidity, dissolved oxygen (DO), specific conductance, and oxygen reduction potential (ORP). Each well was purged until measurements of the stabilization parameters DO and turbidity had stabilized for three successive readings. Field measurements of these stabilization parameters were recorded at routine evacuation intervals (usually 1-liter intervals) using a water quality meter with a standard flow-through cell.

Groundwater was purged from each monitoring well until three consecutive readings of the water quality parameters were obtained that meet the stabilization criteria. Immediately after parameters had stabilized or the well had been purged of the equivalent of three casing volumes, the well was sampled. Samples were collected from the pump discharge point or bailer directly into the appropriate sample container. Sample preservatives were added to sample containers by the laboratory prior to their shipment to the Facility. Groundwater samples were collected at the same flow rates used to purge the wells. Duplicate groundwater samples were collected simultaneously in equal volumes from the same location with the same sampling equipment and placed into identical containers. Duplicate groundwater samples were preserved and handled in the same manner as all other groundwater samples. All groundwater samples were collected and analyzed per protocols established in the Test Methods for Evaluating Solid Waste, USEPA, SW-846 (SW-846, Revision 3, June 1997).

To assess the biasing affect of sediment on groundwater inorganic analytical results, CEMC submitted a letter to MDEQ on May 4, 2012 titled *Request for Modification to Groundwater Sampling and Analysis Plan*, proposing field filtering of the inorganic sample at select monitoring wells (GW-4R, GW-5RR, P2RI-50S, P2RI-51S, and GW-NS) during the second quarter 2012 sampling event. The field filtered sample (submitted for dissolved inorganic analysis) was to be taken in conjunction with a non-filtered sample (submitted for total inorganic analysis) for data comparison. In a response dated May 21, 2012 (just after completion of the second quarter sampling event), MDEQ approved the additional field filtered (dissolved) inorganic samples, and indicated that all groundwater samples in the future be

analyzed for dissolved, rather than total, inorganics. Therefore, beginning with the third quarter 2012 sampling event, the inorganic analysis sample collected from all wells was field filtered using a 0.45 micron filter attachment, prior to submittal for laboratory analysis. The third and fourth quarter 2012 inorganic results are detailed in Appendix 4-I (Table 4-I-1-A).

Data generated during the Phase II RI groundwater sampling events were used to assess the need for future monitoring of these wells and to determine whether additional wells would be required. The results of the Phase II RI groundwater assessment are presented in Chapter 4.0 of this Report.

2.1.3 SURFACE WATER AND SEDIMENT SAMPLING METHODS

The surface water and sediment sampling investigation activities related to the drainages and groundwater seeps on or near the Facility utilized the methods described in the CSM Work Plan and Phase II RI Work Plan FSP. The surface water drainage systems and channels located within the limits of the Facility and in the area surrounding the Facility are ephemeral features, and typically only contain surface water or evident flow after storm events or periods of snow melt. A total of eight surface drainages were identified on or near the Facility that at some point during a year may contain surface water (and possibly sediment). The two groundwater seeps identified are located in one of the surface drainages.

Designated surface water sample locations within the drainages were visually inspected on a monthly basis and after periods of snow melt or periods of significant rainfall (i.e., 0.5 inches of precipitation within a 24-hour period). The drainages were inspected to assess areas of standing surface water, estimate existing runoff volume, velocity, and possible sediment loading. Observations made during the inspections were recorded on field forms and in a field log book designated for surface water drainage inspections.

2.1.3.1 SURFACE WATER SAMPLING

Due to the intermittent presence of surface water in the drainage channels identified at the Facility, surface water sampling events could not follow a specific schedule. Rather, efforts were made to collect samples as soon as possible following the observation of surface water in a drainage channel. Surface water samples were collected from within the main portion of the seep or area of surface water. When possible, samples were collected by immersing the sample containers below the water surface to fill them directly. Alternate collection methods were utilized if surface water was not of sufficient depth to allow for the immersion of sample containers, including the use of lidded sump buckets with holes drilled in the bottom and sides. This allowed seep water to collect in the sump, while limiting the amount of sediment that would enter. Bucket lids prevented the entry of rainwater.

Surface water quality parameters were also collected when possible after the surface water sample collection. An aliquot of surface water was collected in a decontaminated container large enough to hold the water quality probe and the water quality parameters were recorded. The water quality parameters, sample date, time, physical characteristics, and other possible observations of the surface water sample and drainage location were recorded at this time. Field documentation is presented in appendices associated with Chapter 5.0, Surface Water and Sediment.

Samples were submitted for analyses of the constituents on the Facility water COI list, discussed further in Section 2.1.5.

2.1.3.2 SEDIMENT SAMPLING

Sediment investigation activities utilized the methods described in the CSM Work Plan and Phase II RI Work Plan FSP. Sediment sampling was not dependent on the presence of surface water. However, if water was present during sampling, sediment samples were collected from either beneath the water surface or within a few lateral feet of the water's edge. Efforts were made to obtain a relatively undisturbed sample to ensure that it is representative of the in-situ sediment conditions, including the range of sediment particle size. Sample locations were also based on field conditions, with the area of greatest accumulation of sediment being selected for a given sampling location. In some instances, only a thin veneer of sediment was present. At these locations, an effort was made to collect a sufficient aliquot of sample for laboratory analysis by collecting sediments from several localized pockets of accumulation.

As with soil (Section 2.1.1), sediment samples were also analyzed utilizing portable XRF units and PID/FID instruments. A sediment samples from each location was placed in plastic bags and field screened using a portable XRF. If necessary, sediment samples were dried prior to screening with the XRF, as high moisture content can interfere with XRF readings. XRF readings were taken through the bag, PID/FID readings were collected from the headspace within the bag. Instrument field screening and field observations (visual impacts, odor, etc.) allowed field personnel to make real-time decisions pertaining to additional sampling locations and depth intervals collected for confirmation analysis.

During the inspection and completion of sediment sampling within the surface drainages at the Facility during the Phase II RI, it became apparent that Surface Drainage 01 is unique. Surface Drainage 01 is the only drainage with groundwater seeps present and associated saturated areas, and which contains sediment. All of the drainages may convey surface water runoff from the Facility during high-flow precipitation events. However, Surface Drainage 01 is the only drainage that originates from the Facility and which contains "true" aquatic habitat.

The sediment sample date, time, physical characteristics, and description of the extent of contamination (if applicable) of the sample location were recorded on field forms and in a designated field log book. Field documentation is presented in appendices associated with Chapter 5.0, Surface Water and Sediment.

Samples were submitted for analyses of the constituents on the Facility soil COI list, discussed further in Section 2.1.5.

2.1.4 SAMPLE NAMING CONVENTION

A naming convention was established for samples collected during the Phase II RI, the purpose being to distinguish these samples from those collected during prior investigations and thereby facilitate data review and evaluation specific to the Phase II RI. Table 2.1-3 depicts the naming convention used for samples collected during the Phase II RI.

The complexity of the naming convention utilized during the Phase II RI is somewhat related to the media sampled. For example, groundwater monitoring wells newly installed as part of the Phase II RI were named using the “P2RI” prefix, a sequential well number and a suffix related to the hydrostratigraphic units discussed in Section 2.1.2, installation time and/or purpose of the well. Monitoring wells installed during prior investigations (see Chapter 1.0) then modified or replaced during the Phase II RI, utilized the naming convention from the prior investigation combined with a suffix representing the modification made during the Phase II RI. Naming convention for monitoring wells is discussed in more detail in the introduction to Chapter 4.0.

Similarly, surface water and sediment samples were named using the prefix “SD”, a sequential number, and a suffix distinguishing between surface water and sediment samples. Vapor intrusion investigations prescribed in the May 16, 2008 SOW expanded on prior investigations discussed in Chapter 1.0. The naming convention utilized during the 2009 and 2010 VI investigations were the same as those used during earlier investigations and is not included in Table 2.1-3.

The naming convention utilized during soil investigations had to address an overall large area of investigation as well as the specific investigation areas identified by MDEQ in their May 16, 2008 SOW. Naming convention for soil investigation samples consisted of the following:

- A prefix identifying the area of investigation, e.g., “TB” for tank berms, “PC” for former pipeline corridors, “TF” for tank farm, etc. The prefix is also used to indicate whether the sample was a “parent” sample or “step-out” location. For step-out locations, an “S1” or “S2” would be typically added to the sample prefix, e.g., TFS1 would be an initial step-out location associated with the tank farm sampling program.
- A location ID based on an established grid system.

- A suffix that differentiated between surface soil (SS) vs. subsurface soil (DP [direct push]), provided sequential numbering of sample locations within the same grid cell or feature, and the depth of the screening or sampling location in parenthesis following the SS or DP suffix.

A grid system was established for the Facility and surrounding area as follows:

- A grid comprised of 300' x 300' cells was established using available geographic information system (GIS) data for the Facility. Grids were created with a tool in GIS called Create Fishnet.
- Centroids were developed for each grid cell to create center-point features that were used to define where the field sampling would take place.
- Location identifications (IDs) were created for each point based on row/column grid identifiers. Rows were assigned a number, and columns a letter, allowing for alpha-numeric reference to specific cells within the grid.
- Naming convention for screening/sample locations utilized an area or task-specific letter code, cell reference, and a point reference, as described in the preceding paragraph/bullets.
- Point features from the location IDs were uploaded to Global Positioning System (GPS) units for field navigation, allowing field crews to navigate to each point using GPS units.

The Facility grid system can be seen on Figures 3-1 and 3-2. Smaller grids, typically comprised of 50' x 50' cells, were used for some areas of investigation. For example, the tank berm and VCP excavation soil investigations utilized smaller grids established over individual tank berms and former excavation areas to facilitate the placement of field screening/sampling locations. The smaller grids were established in the same manner as the larger Facility grid and an alpha-numeric reference to specific cells within the smaller grid were used to identify sample locations.

The naming convention used for specific media and area investigations is summarized briefly in their respective subsections within Chapters 3.0, 4.0, 5.0 and 6.0.

2.1.5 LABORATORY ANALYSES

Soil, sediment, groundwater, and surface water samples were analyzed for the constituents on the Facility's COI lists for soil and water. The COI lists are presented as Tables 2.1-1 (soil and sediment) and 2.1-2 (groundwater and surface water). The soil COI list was utilized for sediment samples and the groundwater COI list was utilized for surface water and any "miscellaneous" water samples (e.g., residential sumps). The soil COI list differs slightly from that presented in prior documents in that it lists migration to groundwater screening levels (SLs) and site-specific metals background, in addition to direct contact screening levels for residential soils. Only the direct contact levels for groundwater at

0 - 10 ft-bgs are used; these values originate from Table 2 of MDEQ's September 2009 Risk Based Corrective Action (RBCA) guidance document. These changes reflect a modification to the data evaluation process, which is described further in Section 2.3.

Environmental samples and their corresponding quality assurance/quality control (QA/QC) samples were analyzed by Lancaster Laboratories, Inc., located in Lancaster, Pennsylvania. Each sample was analyzed by one or more of the following methods, depending on the media being sampled and the purpose of the area-specific sampling program:

- Volatile Organic Compounds (VOC) by Solid Waste 846 (SW846) Method 8260B
- Semi-volatile Organic Compounds (SVOC) and Tetraethyl Lead by SW846 Method 8270C and SW846 8270C with Selective Ion Monitoring (SIM)
- Volatile Petroleum Hydrocarbons (VPH) by MA-VPH
- Extractable Petroleum Hydrocarbons (EPH) by MT-EPH Screen and MA-EPH
- Total Metals in soil samples (Al, Sb, Ba, Be, Cd, Ca, Cr, Co, Cu, Fe, Mg, Mn, Ni, K, Se, Ag, Na, Tl, Sn, V, and Zn) by SW846 Method 6010B
- Total and Dissolved Metals in water samples (Ba, Cd, Cr, Co, Cu, Pb, V, and Zn) by SW846 Method 6010B
- Total Metals in soil samples (As) by SW846 Method 6020
- Total and Dissolved Metals in water samples (Sb, As, Be, Ni, Se, and Ag) by SW846 Method 6020
- Total Mercury in soil samples by SW846 Method 7471A
- Total and Dissolved Mercury in water samples by SW846 Method 7470A
- Total Cyanide by SW 846 Method 9012A
- Soil Moisture by Standard Method 20th Edition (SM20) 2540 G
- Total Lead in soil samples by Solid Waste 846 (SW-846) Method 6010B

As noted in DEQ-7, Footnote #9, MDEQ requires total metals analysis for surface water. For evaluation of surface water quality at the Facility, CEMC has collected samples from SD01 for total metals analysis, and has also collected samples for dissolved metals analysis, for purpose of evaluating total metals data and the effects that suspended sediment in turbid samples (reacting with nitric acid preservative in sample bottles) may have on analytical results. Dissolved metals data are not compared to applicable screening levels.

Also as noted in DEQ-7, Footnote #9, MDEQ requires dissolved metals analysis for groundwater samples from monitoring wells. Note that groundwater samples collected prior to the third quarter 2012 were submitted for total metals analysis. Total metals samples collected from groundwater monitoring wells represent a more conservative estimate of what may be in groundwater, as the concentration of dissolved metals in groundwater may be lower than the laboratory reported value for total metals. As discussed in Section 2.1.2, samples were collected from selected monitoring wells during the second quarter 2012 and submitted for both total and dissolved metals analysis to assess the biasing affect sediment in water samples may have on inorganic analytical results. Beginning with the third quarter 2012 sampling event, all groundwater samples were field filtered using a 0.45 micron filter attachment and submitted for dissolved inorganic analyses, in accordance with DEQ-7.

Note, in correspondence to MDEQ dated April 15, 2011 (Appendix 2-A), CEMC indicated it had learned analytical results for soil samples collected since mid-2006 from the Facility had been reported by the analytical laboratory on a “wet-weight” basis. MDEQ requires that soil data be reported on a dry-weight basis. This had some impact on the soil data reported in the 2010 CSM Update Report and utilized in the final Phase II RI Work Plan to identify additional soil sampling locations. CEMC has since applied a conversion to the wet-weight results in order to obtain the dry-weight result for all affected soil data for the Facility, as described in the April 15, 2011 correspondence to MDEQ. All soil data reported since the time that CEMC became aware of the error has been reported on a dry weight basis. The conversion applied to the wet-weight results did not affect the quality or usability of the data. Soil investigation results presented in Chapter 3.0 utilize the corrected data. As is discussed in that chapter, the effect this conversion had on soil investigation activities was minimal.

In addition to the above analyses, samples collected from certain investigation areas underwent additional analyses for constituents not listed on the Facility COI lists or to determine waste classification for the purpose of material management/disposal. These additional analyses included:

- Pesticides by SW846 Method 8141A and SW846 Method 8081A – these analyses were limited to investigation activities assessing impacts from non-petroleum sources (discussed in Chapter 3.0, Section 3.9).
- Polychlorinated Biphenyls (PCBs) by SW846 Method 8082 - these analyses were limited to investigation activities assessing impacts from non-petroleum sources (discussed in Chapter 3.0, Section 3.9).
- Herbicides by SW846 Method 8151A - these analyses were limited to investigation activities assessing impacts from non-petroleum sources (discussed in Chapter 3.0, Section 3.9).
- Dioxins, Furans, and Total Homologues by SW846 Method 8290A - these analyses were limited to investigation activities assessing impacts from non-petroleum sources (discussed in Chapter 3.0, Section 3.9).

- Toxicity Characteristic Leaching Procedure (TCLP) Metals in select soil samples (As, Ba, Cd, Cr, Pb, Se, and Ag) by SW846 Method 6010B – this analysis was limited to certain soils with elevated Pb concentration and located within Tank Berms 3, 18, and 34, and on those residential properties where soils originating from Tank Berms 3 and 34 were placed and which exhibited elevated Pb concentration.
- TCLP Mercury in soil samples by SW846 Method 7470A - this analysis was limited to certain soils within tank berm/tank farm areas and on residential properties exhibiting significantly levels of Pb impacts.
- Asbestos in soil samples by USEPA Method 600/R-93/116 – this analysis was limited to soils from the Asphalt, Slag, Cinder areas (discussed in Chapter 3.0, Section 3.3).

These additional analyses were also performed by Lancaster Laboratories, with the exception of the asbestos analysis. That work was performed by EMLab P&K, LLC, located in San Bruno, California. Finally, a number of samples of LNAPL, as well as samples of media (soil, groundwater) that appeared to have significant hydrocarbon impacts were submitted to Alpha Woods Hole Laboratories (Mansfield, Massachusetts) for chemical forensic analyses. The resulting analytical results were interpreted and reported to CEMC by NewFields Environmental Forensics Practice LLC (Rockland, Massachusetts). Samples were also collected and sent to the Chevron Environmental Technology Company's laboratory (Richmond, California) for similar analyses. The results from the forensic analyses and their significance to this Report are discussed in more detail in Chapters 4.0 and 7.0.

2.2 DATA VALIDATION METHODS

This section provides a summary of the methods used to validate data generated during the Phase II RI. Data validation is necessary to identify errors, biases, and physically unrealistic values in project data. Data will not be used in identification of exceedances, any data analysis, or investigations unless that data has been validated. There are three levels of validation that can be performed: Tier I, Tier II, and Tier III.

Tier I: A Tier I validation is performed to document that all samples in the data set were analyzed according to the project requirements, and that the laboratory analytical report is complete. Tier I validations can be performed by any competent person with knowledge of the project requirements.

Tier II: In addition to the Tier I validation requirements the Tier II evaluation includes a review of the results of the analytical procedures, a review of field and laboratory QC tests, assessment of duplicate sample repeatability, and a description of any qualified or rejected data. Tier II validations should be performed by an individual who is familiar with the actual laboratory methods used in generating the data set, and who has a reasonable degree of independence from the project team.

Tier III: In addition to the Tier I and II validation requirements, the Tier III evaluation includes a review of the raw analytical data, which is examined in detail to check for correctness of concentration calculations, compound identification, and anomalies in the data. A detailed data validation report, which provides sufficient detail to explain data qualifiers, and data inadequacies, is produced by the reviewer. The Tier III data validation process provides sufficient detail for the data user to have an accurate idea of the data quality and reliability, and an understanding of how well the project objectives were met. The Tier III data review ensures that the data are adequately assessed, so as to allow its use in formal legal proceedings, risk assessments, and closures. The Tier III data validation is performed by a chemist or other trained scientist who is familiar with contract laboratory procedures.

Tier III data validation was performed on all data generated during the Phase II RI. A detailed discussion of the data validation process can be found in Appendix 2-B. Results of the data validation (DV) process as applied to the specific investigation areas are presented in the corresponding chapters of this document.

Chemical data validation was conducted in accordance with the National Functional Guidelines for organic and inorganic analyses. Data for organic analyses were evaluated according to validation criteria set forth in the USEPA Contract Laboratory Program (CLP) National Functional Guidelines for Superfund Organic Methods Data Review, document number EPA-540-R-08-01, June 2008 with additional reference to the USEPA CLP National Functional Guidelines for Organic Data Review, document number EPA 540/R-99-008, October 1999. Data for inorganic analyses were evaluated according to validation criteria set forth in the USEPA CLP National Functional Guidelines for Inorganic Superfund Data Review, document number EPA 540R-10-011, January 2010 with additional reference to the USEPA CLP National Functional Guidelines for Inorganic Data Review, document number EPA 540-R-04-004, October 2004. Review of field duplicates was conducted according to the USEPA Region 1 Laboratory Data Validation Functional Guidelines for Evaluation of Organic Analysis, December 1996.

The DV process evaluates adherence to Quality Assurance Objectives in accordance with those defined in the Facility Quality Assurance Project Plan (QAPP), quality control and calibration samples, the analytical laboratory's method compliance and completeness, and assigns qualifiers to data undergoing review through this process. These key components are described in the following subsections.

2.2.1 QUALITY ASSURANCE OBJECTIVES

Data obtained during the Phase II RI were evaluated to determine the attainment of quality assurance objectives. This data was evaluated for accuracy, precision, representativeness, completeness and comparability of results in accordance

with the Facility QAPP dated August 14, 2009. Detailed description of these objectives can be found in the DV procedures described in Appendix 2-B, and the Facility QAPP (Appendix 2-C).

2.2.2 QUALITY CONTROL AND CALIBRATION SAMPLES

Quality control samples were analyzed to evaluate the quality of the analytical procedures, identify field and laboratory-introduced contamination, and assess the quality of the analytical results. Calibration samples were analyzed to provide a basis for analyte identification and quantitation. The following are the key data quality elements further defined in the Data Validation Methods Summary and QAPP (Appendices 2-B and 2-C, respectively):

- Blanks
- Initial Calibration and Continuing Calibration
- Laboratory Control Samples
- Matrix Spikes
- Field and Blind Duplicates
- Surrogates
- Instrument Performance Check/Instrument Tunes
- Interference Check Sample
- Serial Dilutions
- Laboratory Duplicates
- Internal Standards

2.2.3 METHOD COMPLIANCE AND COMPLETENESS

In addition to the quality control samples addressed above, the data validation included an evaluation of method compliance based on holding times and preservation and a review of the Chain of Custody (COC) documents to determine completeness.

Holding times are the length of time a sample can be stored after collection and prior to analysis without significantly affecting the analytical results. Holding times vary with the analyte, sample matrix, and analytical methodology used to quantify the analytes concentration. Method holding times and preservation requirements for the methods used in this project are summarized in the detailed description of data validation methods in Appendix 2-B. Preservation

techniques are also employed to reduce biodegradation, volatilization, oxidation, sorption, precipitation, and other physical and chemical processes.

The COC is a chronological record of who has been in possession of the environmental samples and what analyses are to be performed on them. A COC provides assurance that the samples have not been tampered with. The COC completeness evaluation included a review of signatures, dates, sample IDs, and requested analyses.

2.2.4 DATA QUALIFIERS

The purpose of validating data and assigning qualifiers is to assist in proper data interpretation. Data that are not qualified meet the site data quality objectives. If values are assigned qualifiers other than an R (rejected, data not usable), the data may be used for site evaluation; however, consideration should be given to the reasons for qualification when interpreting sample concentrations. Data points that are assigned an R qualifier cannot be used for site evaluation purposes.

Data qualifiers used during the data validations include:

- J – Estimated concentration
- UJ – Estimated reporting limit
- JB – Estimated concentration due to blank contamination
- R – Rejected, data not usable

Data validation results are summarized for each task in the chapters that follow and discussed in detail in Appendix 2-B. In addition to individual data validation summaries provided for each task, detailed Tier III data validation packages are included in the corresponding appendix folders. The Tier III data validation packages include the rationale for any of the data qualifiers listed above, in addition to a calculation of data completeness percentage for each task. Percent data completeness was calculated based upon a review to determine if the number of data records received equaled what was requested, and if all data point were considered valid (i.e., not rejected) during the data validation process. The final data completeness percentage is determined by dividing the number of valid data records by the number of planned records. Data that did not meet the data validation criteria or were not reported by the laboratory were considered invalid. Note that some data points associated with the Phase II RI were qualified as rejected, but did not affect the data evaluation conclusion(s). The percent data completeness for each individual task were all greater than 90%, which was the objective proposed in the Facility's approved QAPP.

2.3 DATA EVALUATION PROCESS

Data evaluation varies by media. The methods utilized during the Phase II RI followed MDEQ published guidance, unless otherwise directed or agreed to by MDEQ, and are presented in the following sections.

2.3.1 SOIL AND SEDIMENT

The results of the Phase II RI soil and sediment investigations are presented in Chapters 3.0 and 5.0, respectively. Comparison of data to screening levels is part of the evaluation process and these comparisons are presented on figures and in the summary tables associated with those chapters. Complete data tables are included in the tables and/or appendices associated with those chapters. Development of background values for specific COIs and comparison of investigation data to those values is also part of the evaluation process. Development of background values for soil and its role in the data evaluation process are discussed in the following sections.

2.3.1.1 SOIL

For soil, the screening process followed the flow chart presented on the MDEQ Website (MDEQ 2012a), as discussed with MDEQ (Cote 2012a).

An initial evaluation of site-specific background concentrations of inorganic constituents was presented to MDEQ via correspondence dated May 7, 2012. Those calculations included results for soil samples collected within the former refinery property footprint. During a meeting on May 31, 2012, MDEQ indicated the agency would not approve calculations that utilized soil data collected from areas within the former refinery where above-ground storage tanks were located. Subsequently, in accordance with the May 31, 2012 discussions with MDEQ, the document was revised, utilizing a data set limited to samples collected from non-impacted portions of the tank farm area. That revised data set and the associated calculations were presented to MDEQ via a July 18, 2012 correspondence entitled *Revised Background Evaluation, Metals Concentrations in Soil, Former Texaco Sunburst Works Refinery, Sunburst Montana* (CEMC 2012d).

In a letter dated August 31, 2012, MDEQ rejected the July 18, 2012 revised evaluation because the data set included samples from areas that MDEQ believed potentially could be impacted. Via the August 31, 2012 correspondence, MDEQ requested a work plan be submitted to describe proposed procedures for re-evaluating background concentrations for inorganic constituents, with the data set limited to samples collected at least 500 feet from the former refinery property boundary. The resulting work plan, *Background and Data Gap Sampling Work Plan for Off-Site Soils and Surface Water and Sediment in Drainage SD01 and the Lakebed* (CEMC 2013a, submitted December 3, 2012, revised and resubmitted January 28, 2013), was approved by MDEQ on February 13, 2013. The procedures in

that approved work plan were followed to recalculate background concentrations of inorganic constituents, as reported in a June 3, 2013 document entitled *Background Evaluation, Metals Concentrations in Soil, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2013c). This document is provided in Appendix 2-D. The calculated background values are also provided on the Facility soil COI list (Table 2.1-1) and in the soil data summary tables that accompany Chapter 3.0. MDEQ conditionally approved the background values presented in the June 3, 2013 submittal in correspondence dated June 12, 2013.

The screening process utilized in preparation of this Report is slightly different than that presented in the CSM Update and CSM Update Addendum, and Phase II RI Work Plan. However, these differences have had only minor effects on screening results and do not affect the conclusions presented in this Report. The differences in the screening process between the CSM Update Report and this Report are summarized as follows:

- In the CSM Update Report and CSM Update Addendum, soil from the former tank farm area was screened against MDEQ RBSLs based on commercial use. In this Report, all soil screening has been conducted with respect to screening levels based on residential use.
- In the CSM Update Report, screening was conducted only for constituents for which MDEQ had established RBSLs. In this Report, the most recent (May 2013) USEPA Regional Screening Levels (RSLs) (both direct contact- and migration to groundwater- based) have been used for screening of constituents without MDEQ RBSLs.
- In this Report, the depth from surface soil to groundwater is assumed to be less than 10 feet. While the depth to groundwater is typically greater than 10 feet in the tank farm areas described in the CSM Update reports, areas in the eastern portion of the site have shallower groundwater. Hence, the more conservative assumption is used here for the entire Facility.
- The soil moisture correction that was applied to the soil data (see discussion in Section 2.1.5) may have a small bearing on the screening results. In this Report, soil data are reported as dry weight.
- Background soil concentrations have been used as part of the soil screening process for metals in this Report.
- In this document, separate screening has been conducted relative to screening criteria based on human health risk due to direct contact, and screening criteria based on potential for leaching of constituents to groundwater.

The screening process used in this Phase II RI Report is described in additional detail below.

Screening levels for the COIs are presented in Table 2.1-1. Separate screening levels are shown for direct exposure (Part 1 of the MDEQ flowchart) and leaching to groundwater (Part 2 of the MDEQ flow chart). In the summary tables

in Chapter 3.0, separate screening results are presented for each of these end points. Presentation of screening results based on these two end points is intended to provide decision makers with the ability to consider the endpoints in remedial action decisions. Additionally, it provides information necessary to make remedial action decisions regardless of the classification of groundwater.

As discussed in Section 1.3.2, CEMC evaluated groundwater data from 1990 through 2011 to assess the classification of groundwater at and near the Facility. Based on that evaluation, the shallow groundwater beneath Sunburst meets the criteria for classification as Class IV groundwater as specified in Montana Water Quality Rule 17.30.1006, Section (4). The evaluation results and request for determination by MDEQ that the shallow groundwater beneath the Facility is Class IV (*Classification of Groundwater*) was submitted to MDEQ on August 31, 2012 (CEMC 2012f). MDEQ approved the document, concluding that groundwater at the Facility meets the definition of Class IV groundwater, as provided in ARM 17.30.1006. Appendix 1-C includes the groundwater classification determination submittal.

According to Montana Water Quality Rule 17.30.1006, Section (4)(b) and (c), for groundwater designated as Class IV, human health standards for groundwater apply to carcinogens, while acceptable levels for non-carcinogens in groundwater are not allowed to increase to a point of adversely affecting existing beneficial uses. This portion of the rule is quoted below.

(b) Except as provided in (5) and ARM 17.30.1005(2), a person may not cause a violation of the following specific water quality standards for Class IV ground water:

- i. the human health standards for parameters categorized as carcinogens in DEQ-7;
- ii. for concentrations of parameters in DEQ-7 which are not listed as carcinogens, any increase of a parameter to a level that would adversely affect existing beneficial uses. The nitrate nitrogen and nitrate plus nitrite nitrogen standards are each 50 milligrams per liter (mg/L);
- iii. for concentrations of parameters for which human health standards are not listed in DEQ-7, no increase of a parameter to a level that would adversely affect existing beneficial uses. The department may use any pertinent credible information to determine these levels.

(c) The non-degradation provisions of 75-5-303, MCA, do not apply to Class IV ground water.

There currently are no existing beneficial uses of the shallow groundwater beneath Sunburst. Based on the groundwater evaluation and corresponding discussions with MDEQ (Cote 2012b), this section is interpreted to indicate that the leaching to groundwater standards for non-carcinogens do not apply to Class IV soils above Class IV groundwater. Therefore, the screening results for the leaching to groundwater endpoint for non-carcinogens are shown

in ~~strike through~~ font in Table 2.1-1 and in the summary tables in Chapter 3.0. The symbols on the figures in Chapter 3.0 indicate locations of exceedances of direct contact screening levels for carcinogens and non-carcinogens and exceedances of leaching to groundwater screening levels for carcinogens.

Screening criteria were established for both surface soil (< 2 ft-bgs) and subsurface soil (> 2 ft-bgs) as specified in the MDEQ document titled *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Release Sites* (MDEQ 2009a). For constituents with MDEQ risk-based screening levels (RBSLs) the RBSLs in Appendix C of MDEQ 2009a were used as screening levels. For direct contact exposure, the residential direct contact RBSL was used as the screening level for surface soil. The direct contact RBSL for excavation (Appendix C; MDEQ 2009a) was used for subsurface soil (Table 2; MDEQ 2009a). For the leaching to groundwater pathway, the RBSLs in the first column of Appendix C were used as the screening level for both surface and subsurface soil. These screening levels incorporate the assumption that the vertical distance between the sample and the groundwater table is less than 10 feet. As described in the CSM Update Addendum, the depth to groundwater is greater than 10 ft-bgs beneath most of the Facility. Therefore, for many locations, the assumption that the vertical distance between the sample and groundwater table is less than 10 feet is a conservative one for surface soil.

The RBSLs in Appendix C of MDEQ 2009a are expressed with between one and six digits. The RBSLs in Tables 1 and 2 of MDEQ 2009a have been rounded to one significant figure. For screening levels that are based on RBSLs, CEMC has used MDEQ's rounding convention in developing the SLs in Table 2.1-1.

Per MDEQ guidance, the USEPA Regional Screening Levels (USEPA 2013a) were used to evaluate constituents that have not been assigned Montana RBSLs. The MDEQ soil screening flow charts were used to assign these screening levels.

The background soil concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Therefore, for these constituents the MDEQ-approved background concentrations (CEMC 2013c, Appendix 2-D) were used. These values are:

Arsenic: 25.1 mg/kg

Cobalt: 9.13 mg/kg

Vanadium: 63.9 mg/kg

MDEQ has established a state-wide background concentration for arsenic of 40 mg/kg (MDEQ 2007). In evaluating data from the Facility, CEMC has used the lower, site-specific value of 25.1 mg/kg. It should be noted that the

background concentrations above have been calculated using USEPA methods (USEPA 2010). The background concentrations are generally based on an upper tolerance limit which is a statistical limit below which typical (unimpacted) sample constituent concentrations would lie 90% of the time with 95% confidence. This means that up to 10% of typical (unimpacted) soil may reasonably exceed this value. Therefore, in the data evaluation descriptions in Chapter 3.0, the percent of soil results that exceed the background value are described for arsenic, cobalt, and vanadium. Soil results above the background concentrations for these metals are not reflected in the symbols on the figures in Chapter 3.0, as exceedances of these background concentrations are not believed to be indicative of a refinery source, but are likely in the upper bounds of natural variability for those metals.

As described in the paragraphs above, metals concentrations in soil were evaluated with respect to three different criteria; direct contact-based screening levels, leaching-based screening levels, and site-specific background concentrations. For arsenic, cobalt, and vanadium, the applicable screening level was the site-specific background concentration and therefore the background value and number of exceedances of background are shown in **BOLD** in the summary tables in Chapter 3.0. For all other (non-carcinogenic) metals, the applicable screening level is the direct contact-based value and the corresponding columns are shown in **BOLD**, on the summary tables in Chapter 3.0. Furthermore, this value is used as the screening criteria on the figures in Chapter 3.0. This has important implications for the screening evaluation of lead, which MDEQ has indicated is the primary metal of concern at the Facility. The direct contact value (400 mg/kg) has been used as the screening criteria for lead on the figures. This approach is the same one that was used in the CSM Update and CSM Update Addendum. It is also consistent with MDEQ's approach to evaluating lead, based on the MDEQ soil screening flow chart and discussions with MDEQ.

2.3.1.2 SEDIMENT

For sediment, data for constituents with RBSLs have been compared to the residential direct contact-based RBSL in Appendix C of the MDEQ document titled *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Release Sites* (MDEQ 2009a). Sediment data for constituents without RBSL have been compared to direct contact-based RSLs (USEPA 2013a). This approach is consistent with that followed in the CSM Update and CSM Update Addendum. The acceptability of the screening approach used in this Report was verified during a phone call on August 2, 2012 (Cote 2012b). However, for ecological risk assessment purposes, sediment data will be compared to USEPA Region 3 Biological Technical Assistance Group (BTAG) screening levels.

During a May 31, 2012 meeting with MDEQ, the need for collection of background sediment samples to support the Ecological Risk Assessment (ERA) portion of the upcoming RAA for the Facility was discussed. It was agreed background samples would be collected for the following media and locations:

- Surface water in Surface Drainage 01
- Sediment in Surface Drainage 01
- Surface water in the unnamed lake located east of the former refinery
- Sediment in the bed of the unnamed lake

A work plan proposing collection of samples for determination of background metals concentrations in surface water and sediment in Surface Drainage 01 and the unnamed lakebed was first submitted to MDEQ on June 11, 2012 (*Background Sampling Plan, Metals and Polynuclear Aromatic Hydrocarbons (PAHs) Concentrations in Sediment and Surface Water* [CEMC 2012c]). That work plan was revised several times based on input from MDEQ, and a final approach for collection of background metals data was approved February 13, 2013 (CEMC 2013a). Sediment samples for determination of background concentration were collected in late March 2013. Those data have been evaluated and discussed with MDEQ, and proposed background metals concentrations in surface water and sediment were presented in a September 23, 2013 submittal to MDEQ (*Technical Memorandum, Background and Data Gap Sampling Results and Background Evaluation, Metals Concentration in Sediment and Surface Water* [CEMC 2013d]). MDEQ approved the proposed background values in correspondence dated October 3, 2013, and surface water and sediment data presented in Chapter 5.0 of this Report have been compared to those background concentrations.

2.3.2 GROUNDWATER AND SURFACE WATER

Laboratory analytical results from the Phase II RI groundwater monitoring and surface water events were compared to standards established by MDEQ. The process for establishing screening standards is discussed in the MDEQ Frequently Asked Questions (FAQs) section of the website

<http://deq.mt.gov/StateSuperfund/FrequentlyAskedQuestions.mcp>, and involves a hierarchy of sources as follows:

- Montana Numeric Water Quality Standards Circular-7 (DEQ-7, MDEQ 2012c) or maximum contaminant levels (MCLs)
- Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases (RBCA, MDEQ 2009a)
- The most recent version of the tapwater Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (<http://www.epa.gov/region9/superfund/prg/>)

For purposes of the constituent results summaries presented in Chapters 4.0 and 5.0, the applicable regulatory limit is referred to as the “MDEQ standard”. Note that for surface water, there are no standards for VPH or EPH and therefore, no comparisons were made.

As with sediment and soil, a background data set was developed for surface water, focusing on specific COIs (metals). Surface water background values were developed in conjunction with sediment background, as discussed in Section 2.3.1.2. Comparison of investigation-derived surface water data to MDEQ-approved background concentrations are presented in Chapter 5.0 of this Report.

3.0 SOIL INVESTIGATION RESULTS

The investigations summarized in the following sections were conducted in accordance with the MDEQ-approved CSM Work Plan and Phase II RI Work Plan, and the CEMC November 5, 2010 correspondence regarding soil step-out sampling. These documents were prepared in response to the MDEQ May 16, 2008 SOW for the Phase II RI and subsequent related MDEQ correspondence. The following sections summarize the investigation activities and their results for the areas specified in the May 2008 SOW. The summaries include discussions of both initial investigation activities and follow-up delineation or “step-out” sampling that was conducted based on initial investigation results. The rationale for determining step-out locations and sampling procedures are outlined in the Phase II RI Work Plan and the CEMC November 5, 2010 correspondence. Tables 2.2-1, 2.2-2, and 2.2-3 of the Phase II RI Work Plan presented a concise summary of the initial investigation locations requiring additional delineation sampling. These tables have been updated to correlate the initial or “parent” location IDs with the step-out locations, and to include the additional delineation samples that were collected based on:

- Field screening indicating a need for additional delineation
- Sampling requested by MDEQ via their correspondence date October 15, 2010
- Soil moisture data correction

Parent samples, delineation rationale and corresponding step-out sample IDs are presented in Tables 3-1 (lead) and 3-2 (organics) of this document.

In addition to discussing initial investigation and step-out sampling activities, the following sections summarize the data validation and data evaluation results for each soil investigation area. Note that the number of samples collected for each investigation area may appear to vary between the data validation and data evaluation discussions. The data validation process, described in Section 2.2, includes an evaluation of replicate and duplicate samples collected as part of the QA/QC process. The data evaluation process does not include a review of those samples. As a result, the number of samples referenced for a particular investigation area may vary between those two discussions.

Data collected during the investigation are appended to the Report. Tabulated laboratory data are provided in Appendix 3-A. Field forms and boring/lithologic logs; field XRF data and instrument calibration logs; laboratory reports; and data validation reports are provided on the enclosed USB flash drive as Appendices 3-B through 3-E, respectively. Additionally, Appendix 3-F provides a compilation of the data validation results summaries that are presented for each soil investigation areas in the following sections.

A number of figures have been developed to support the information in the following sections and visually depict the laboratory data presented in Appendix 3-A. Figures specific to a subsection are referenced within that section and numbered accordingly. However, several figures have also been developed to present an overview of multiple investigation areas and the results for those area investigations. Analytical and field screening results are presented in comparison to screening levels that were developed following the data evaluation process described in Section 2.3.1. The overview figures include:

- Figure 3-1: Surface Soil Sampling Overview Map – this figure depicts locations from which surface soil samples were collected and submitted for laboratory analysis. Sample locations are shown in various shapes and/or colors to indicate specific investigation areas.
- Figure 3-2: Subsurface Soil Sampling Overview Map – this figure depicts locations from which subsurface soil samples were collected and submitted for laboratory analysis. Sample locations are shown in various shapes and/or colors to indicate specific investigation areas.
- Figure 3-3A: Summary of Surface Soil Sample Analytical Results – this figure presents analytical and field screening results for surface soil samples collected from the western portion of the Facility.
- Figure 3-3B: Summary of Surface Soil Sample Analytical Results – this figure presents analytical and field screening results for surface soil samples collected from the eastern portion of the Facility.

Figure 3-4A: Summary of Subsurface Soil Sample Analytical Results – this figure presents analytical and field screening results for subsurface soil samples collected from the western portion of the Facility.

- Figure 3-4B: Summary of Subsurface Soil Sample Analytical Results – this figure presents analytical and field screening results for subsurface soil samples collected from the eastern portion of the Facility.

3.1 TANK BERMS

Investigation activities for tank berms associated with former refinery operations were conducted in accordance with the CSM Work Plan (CEMC 2009e) and MDEQ correspondence of September 22, 2009, entitled *Texaco Sunburst Works Refinery, Data Collection Activities for Updating Conceptual Site Model Work Plan* (MDEQ 2009b). This correspondence from MDEQ provided clarification on issues/questions posed by CEMC following submittal of the CSM Work Plan, and in doing so, altered some of the procedures outlined in that document. At the request of MDEQ, the CSM Work Plan was not modified to reflect these procedural changes. Changes to investigation procedures were presented in the CSM Update Report, as were the results of those investigations. Additional investigation activities, based on the information presented in the CSM Update Report, were outlined in the Phase II RI Work Plan.

Tank berm locations and numbering are depicted on Figures 3-1 and 3-2. Soil investigation activities for the former tank berms targeted both surface and subsurface soils, as defined in Chapter 2.0, Section 2.1 of this document, and are summarized in the following sections.

3.1.1 SURFACE SOIL INVESTIGATION METHODS

Surface soil investigation methods involved a combination of screening for metals using portable XRF units and laboratory analysis for a percentage of those screenings, as described in Section 2.1.1. Samples collected for laboratory analysis were analyzed for metals to confirm XRF screening results. Additionally, a portion of the samples were analyzed for the remaining constituents on the Facility COI list, in accordance with the procedures outlined in the September 22, 2009 MDEQ correspondence (MDEQ 2009b).

3.1.1.1 INITIAL INVESTIGATION/SUMMARY OF PREVIOUSLY REPORTED RESULTS

Initial tank berm surface soil investigations involved the use of a 50' x 50' grid of rectangular cells placed over each tank berm, which was established using the procedures summarized in Section 2.1.4. Following establishment of the sampling grids, field personnel conducted XRF in-situ screening in tank berms, as well as the on-property portion of the former tank farm area (with "on-property" defined as the property owned by CEMC at the time of the investigation). Upon completion of in-situ screening, field figures were created depicting the tank berm and tank farm XRF screening results for Pb. These figures were later used to select ex-situ XRF screening locations, XRF confirmation sample locations, and, in part, subsurface boring/ sampling locations.

The naming convention for these samples consisted of the in-situ XRF location ID with "SS" (indicating surface soil) added to the last digits followed by the depth interval in parentheses, e.g., TB08-F02-SS01(0.5-1 ft). The rationale for selecting XRF ex-situ screening locations, selected locations, XRF screening results, and confirmation sample locations was recorded on soil sampling field forms. The XRF soil sampling field forms and corresponding field figures are presented in Appendix 3-B.

XRF in-situ and ex-situ screening/confirmation sampling were conducted simultaneously in off-property tank berms and tank farm areas (with "off-property" defined as those areas not owned by CEMC). XRF screening of all tank berms occurred during the September 2009 – January 2010 timeframe. XRF screening and confirmation sample locations are depicted on Figure 3-1.

There were slight differences in XRF ex-situ screening/confirmation sampling methods between on-property and off-property tank berms, due primarily to procedural modifications discussed in MDEQ 2009b. XRF ex-situ screening/confirmation sampling methods are presented below.

On-Property Tank Berms

As outlined in the CSM Work Plan, 10 percent of XRF in-situ locations were selected for ex-situ screening. Ex-situ screening was conducted following completion of subsurface borings so that information generated during those activities could be considered in selecting ex-situ locations, along with visual observation of impacts and in-situ screening results. Ex-situ locations were pre-determined but modified as necessary while in the field. Locations were modified to target those areas where impacts were noted in previous activities.

Surface soil borings were installed, screened and sampled following the methods discussed in Section 2.1. Soil was collected from the sample core at intervals of 2-6 in-bgs, 6-12 in-bgs, 12-18 in-bgs, and 18-24 in-bgs, placed into plastic bags, and screened using the XRF unit. The 0-2 in-bgs interval was not re-screened during ex-situ screening activities. Soil samples from the 0-2 in-bgs interval, when needed for confirmation analysis, were collected using a stainless steel hand trowel.

The number of samples required for confirmation analysis was determined by combining the total number of in-situ and ex-situ screenings and taking 10 percent of that number. As such, the number of XRF ex-situ locations and confirmation samples were dependent upon the number of grid cells in a particular tank berm. For example, a tank berm with a grid comprised of 50 cells would have 5 ex-situ XRF locations and require the collection of a minimum of 7 samples for confirmation analysis. This would have been calculated as follows:

- 50 in-situ XRF locations, based on the number of grid cells
- 50 in-situ locations X 10 percent = **5 ex-situ XRF locations**
- 5 ex-situ locations X 4 additional screening intervals = 20 ex-situ XRF screenings
- 50 in-situ screenings + 20 ex-situ screenings = 70 total XRF screenings
- 70 total screenings X 10 percent = **7 samples required for confirmation analysis**

Analyses were based on the depth interval from which soil was collected (analytical method number in parentheses):

- 0-2 in-bgs interval – Pb, Metals (6010), Tetraethyl lead (8270), As (6020), Hg (7471), Total Cyanide (9012A), semi-volatile organic compounds (SVOCs, 8270), total extractable petroleum hydrocarbons (EPH, MT-EPH)
- 2-6 in-bgs, 6-12 in-bgs, or 12-18 in-bgs interval – Pb, Metals (6010), As (6020), Hg (7471)
- 18-24 in-bgs interval – VOCs (8260), total volatile petroleum hydrocarbons (VPH, MT-VPH)

If during screening an interval was determined to be impacted, i.e., Pb > 400 ppm, analyses for the full COI list were conducted on that interval. If several intervals at the same location were impacted, analyses for the full COI list were conducted on the interval with the highest Pb screening result.

In the interest of maintaining consistency, laboratory confirmation samples were collected from the 0-2 in-bgs and 18-24 in-bgs intervals at every location that underwent ex-situ screening. Samples collected from these intervals were managed as separate samples, i.e., not composited. However, each of those intervals underwent analyses for different constituents on the soil COI list. For evaluation purposes, these two intervals together were considered to comprise **one** confirmation sample. The purpose for treating the combined intervals as one sample was to represent the full COI list at the majority of ex-situ locations, recognizing that the shallower intervals such as the 0-2 in-bgs would be less likely to contain VOCs. Samples were then collected from a sufficient number of “middle” intervals (2-6 in-bgs, 6-12 in-bgs, or 12-18 in-bgs) to reach the required number of confirmation samples.

The naming convention for screening and sample locations collected during the tank berm soil investigation program is presented in Table 2.1-3. Surface soil locations are noted with the “SS” suffix.

Off-Property Tank Berms

Again as outlined in the CSM Work Plan, a more conservative approach was taken for off-property tank berms. XRF ex-situ screening was conducted in each of the tank berm grid cells (50' x 50'). The number of confirmation samples collected represented 10 percent, at a minimum, of the total number of XRF screenings. The sample tank berm grid described above would result in 25 samples collected for laboratory confirmation analyses, calculated as follows:

- 50 boring/screening locations, based on number of grid cells
- 50 locations X 5 intervals (in-situ and ex-situ screening combined) = 250 screenings
- 250 X 10 percent = 25 confirmation samples

Confirmation samples were also collected from any interval that screened between 280 ppm Pb and 400 ppm Pb. The number of samples collected from the 280 – 400 ppm Pb range was incorporated into the required 10 percent. Samples were collected from all screenings in that range, whether they represented more than 10 percent of total screenings, or met 10 percent. For example, if 35 screenings fell within the 280 – 400 ppm range, samples would be collected from all screenings and submitted for analysis. If no screenings fell within the 280 – 400 ppm Pb range, the number of samples would remain within the 10 percent and locations for sample collection would be based on spatial distribution and representation of the range of XRF screening values encountered.

As with the on-property tank berms, analyses conducted were based on the depth interval from which soil was collected, with the slight variation that the 18-24 inch interval was analyzed for the 8 Resource Conservation and Recovery Act (RCRA) metals, in addition to VOCs and VPH. Again, if an interval was determined to be impacted during screening, i.e., Pb > 400 ppm, laboratory analyses for the full COI list were conducted on that interval. If several intervals at the same location were impacted, laboratory analyses for the full COI list were conducted on the interval with the highest Pb screenings.

Detailed discussions of the tank berm surface soil investigations, including deviations from approved work plans, are presented in the CSM Update Report.

Previously Reported Results

Results from the tank berm surface soil sampling program were previously reported in the March 1, 2010 CSM Update Report and presented in Tables 3.1-2 to 3.1-5 of that document. The tables provided statistical summaries of surface soil data from tank berms, including maximum detected concentration, frequency of detection, and maximum detection limit. Additionally, the data were compared to relevant screening criteria/risk-based screening values. A summary of exceedances was presented at the end of the tables.

Screening criteria presented in the CSM Update Report, and again in the CSM Update Addendum, were developed as specified in the MDEQ document titled *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Release Sites* (MDEQ 2009a). The MDEQ Tier I evaluation tables RBSLs for surface soil (0-2 ft-bgs) and subsurface soil (> 2 ft-bgs). The tables also show the basis for the RBSL (direct contact, potential leaching to groundwater, or adverse effect to beneficial use [generally foul odor]), and surface soil RBSLs are provided for residential and commercial land use. For RBSLs that are based on the potential for leaching to groundwater, multiple values are provided based on different depths to groundwater. MDEQ provides RBSLs for hydrocarbon ranges and for selected risk-driving, petroleum-related VOCs and SVOCs. The RBSLs used for screening tank berm surface soil data and rationale for selecting applicable RBSLs were presented in Section 3.1.4 of the CSM Update Report.

As noted in Section 2.3 of this document, the process used to evaluate data presented in this document has been slightly modified from that presented in the CSM Update Report. The differences between the screening processes are described in Section 2.3.1. One notable difference is that for on-property tank berms, previously reported results referenced both commercial and residential screening levels for lead. Results reported in this document use only residential screening levels.

Summary conclusions presented in the CSM Update Report include the following:

- The nature of soil impacts in the former tank berms is consistent with the historical use as a tank farm for storage of hydrocarbon. The primary constituents detected include hydrocarbon fractions, hydrocarbon-related VOCs and SVOCs, and lead. The most frequently detected constituents correspond closely with those for which MDEQ has established screening criteria in the document titled *Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases* (MDEQ 2009a).
- Surface lead impacts with detected concentrations above both the residential Resource Conservation and Recovery Act Metals Screening Level (RMSL) (400 mg/kg) and commercial RSL (800 mg/kg) exist in Tank Berms 3, 15, 18, 30, and 32. Corresponding subsurface (> 2 ft-bgs) locations of elevated lead occur in Tank Berms 3, 18, and 30, and at one location in Tank Berm 5. The elevated lead concentrations were only detected at depths shallower than 5 ft-bgs. The lead impacts are fairly localized and well defined using a combination of field and analytical data. The lead impacts do not correspond with elevated concentration of hydrocarbon constituents in Tank Berms 3, 15, and 18, but may be associated with hydrocarbon in Tank Berms 30 and 32. Tetraethyl lead was not detected in any soil samples. Limited additional sampling will be completed to determine the estimated volume of soils impacted with high levels of lead in order to identify those which are characteristically hazardous for lead (i.e., TCLP lead results greater than 5.0 mg/L). A confirmation sample may be considered for one location (TB19-G01-SS01) where a field detection above 400 mg/kg was not confirmed by laboratory analysis.
- Concentrations of petroleum hydrocarbon related constituents (VPH, EPH, VOCs or SVOCs) above the MDEQ RBSL for both commercial and residential scenarios were detected in surface soil in Tank Berms 11, 12, 25 and 30. Detected impacts at Tank Berms 25 and 30 are characterized primarily by volatile hydrocarbons. Those at Tank Berms 11 and 12 are characterized by SVOC and EPH fractions. These areas are fairly well delineated by the current soil analytical results. Limited additional delineation sampling may be warranted.
- Concentrations of one or more hydrocarbon constituent exceeded the respective MDEQ residential RBSL(s) at one or more locations in surface soil in Tank Berms 3, 5, 7, 10, 11, 12, 17, 18, 21, 25, 30 and 31. Concentrations of hydrocarbon constituents did not exceed the respective MDEQ commercial RBSLs. These locations are on property owned by CEMC, and CEMC does not intend to redevelop the property for residential use. Therefore, it is recommended that these areas be addressed as part of the site-specific risk assessment. Additional sampling activities should be targeted toward supporting the risk assessment.
- Concentrations of one or more polynuclear aromatic hydrocarbons (PAHs) exceeded the respective MDEQ residential RBSL(s) at one or more locations in surface soil in Tank Berms 27, 28, and 36. One sample from Tank Berm 28 also had concentrations of EPH (C11-C22, aromatic fraction) above the MDEQ residential RBSL.

- Based on the analytical results, the following tank berms did not show evidence for a hydrocarbon release in the surface soil, and no further action is recommended: Tank Berms 1, 2, 4, 6, 8, 9, 14, 16, 20, 22, 23, 24, 26, 33, 35, 37, 38, 39, and 40. Tank Berm 19 may also fall into this category pending confirmation of a field screening result for lead. Also, Tank Berm 34 did not show evidence of hydrocarbon release, although it is known that releases from this tank occurred during the refinery's operational period. However, by the time of the Phase II RI sampling, that tank berm had undergone prior remedial actions to remove lead and petroleum-related constituents in surface and subsurface soils. These prior actions are discussed in Section 3.10 and Chapter 8.0.

Activities to address additional delineation, based on the above recommendations, were detailed in the Phase II RI Work Plan and are summarized in the following Section 3.1.1.2 of this document.

Although the data evaluation process followed in this Report differs from that used in the CSM Update Report, these differences have had minor, if any, impact on the overall conclusions regarding the tank berm soils. Section 3.1.5 of this Report presents an evaluation of all the tank berm soil data collected to date using the evaluation methodology described in Section 2.3.1.

3.1.1.2 STEP-OUT AND/OR DELINEATION SAMPLING

Section 2.2.2 of the Phase II RI Work Plan discussed proposed sampling activities to further delineate tank berm soils. The proposed investigations were based on the information presented in the CSM Update Report and the addendum to the CSM Update Report. As summarized in those documents, Pb, VPH, EPH, and petroleum hydrocarbon-related VOCs and SVOCs were the primary constituents that exceeded RBSLs in surface and/or subsurface soil in the tank berm areas. Delineation of subsurface soils is discussed in Section 3.1.2 of this document.

The proposed investigation activities were also based on discussions with MDEQ during a meeting on June 17, 2010, during which MDEQ requested that the criteria for conducting additional investigation include comparisons to USEPA RSL or Soil Screening Levels (SSLs) for constituents without MDEQ RBSLs. Delineation locations were selected to address Pb concentrations above the USEPA residential RSL (400 mg/kg) and VPH, EPH, VOC and SVOC concentrations above MDEQ RBSLs, USEPA RSLs, or SSLs (multiplied by 10 as requested by MDEQ). It was further agreed during the June 17, 2010 meeting that delineation samples would be analyzed only for those constituents detected in the sample which exhibited screening criteria exceedances. Additional delineation samples would be collected as necessary to delineate the extent of impacts.

The proposed delineation locations were presented on Figures 2.2-1 and 2.2-2 of the Phase II RI Work Plan. The rationale for those locations was presented in Tables 2.2-2 and 2.2-3 of that same document. Surface soil delineation

activities were conducted in August 2010, following the procedures described in Section 2.1 of this document, including screening/sampling of four surface soil intervals (0-6 in-bgs, 6-12 in-bgs, 12-18 in-bgs, and 18-24 in-bgs) as opposed to the five intervals (0-2 in-bgs, 2-6 in-bgs, 6-12 in-bgs, 12-18 in-bgs, and 18-24 in-bgs) utilized during the initial investigation. During review and finalization of the Phase II RI Work Plan, MDEQ indicated the 0-2 in-bgs and 2-6 in-bgs intervals could be combined into one 0-6 in-bgs interval for future surface soil screening/sampling activities, thereby reducing the number of intervals from five to the four described in Section 2.1.

As discussed above, Tables 3-1 and 3-2 of this document present a correlation between the IDs for the initial or parent locations and their corresponding step-out or delineation locations. The naming convention used for location or sample IDs is discussed in Section 2.1.4 and presented in Table 2.1-3. Note that sample prefixes may have changed between parent and step-out locations. For example, initial samples collected from tank berms utilized the prefix “TB”. However, corresponding step-out locations more often than not utilize the prefix “TF”. Many of the proposed step-out sample locations associated with tank berms were located outside of the berm itself. Therefore the tank farm or “TF” prefix was used in the sample naming convention. Tables 3-1 and 3-2 provide the link between parent and step-out samples.

3.1.2 SUBSURFACE SOIL INVESTIGATION METHODS

Subsurface soil investigation methods involved a combination of field screening for metals using portable XRF units, field screening for VOCs using PID/FID units, and laboratory analysis of select intervals from a soil core, as described in Section 2.1.1. The subsurface soil boring program conducted within tank berms was designed to identify possible disposal areas that may be present within the tank berms and possibly pose a continuing source for groundwater contamination. Investigations focused on areas within the berm most likely to contain depressions or waste areas, as well as allow easy access to the tank. The process for identifying the area within a tank berm most likely to represent a disposal location is summarized in Section 3.1.2.1 and further detailed in the CSM Data Collection Work Plan.

Tank berm subsurface investigations were originally presented in the March 1, 2010 CSM Update Report and are summarized in the following sections.

3.1.2.1 INITIAL INVESTIGATION

Soil borings were installed in both on-property and off-property tank berms during September – December 2009, following the procedures outlined in the CSM Data Collection Work Plan, and summarized in Section 2.1.1 of this document. This work proceeded concurrently and in conjunction with the XRF screening and confirmation analysis sampling program. The actual installation procedures, associated field screening activities, sample collection methodologies, and sample analyses did not vary between on-property and off-property tank berms.

All of the on-property tank berms and several of the off-property tank berms (Tank Berms 19, 27 and 28) are relatively “undisturbed” in that much of the original contours of the berms, including the footprint of the former tanks, were discernible in the field. Boring locations were selected prior to installation. In these undisturbed tank berms, boring locations were selected based primarily on field observations, taking into account depressions, mounds, location of the tank footprint, potential access points, and upslope/downslope areas based on surface topography. Selected boring locations were assigned an ID, using the grid system and accompanying row/cell identifiers established for individual tank berms (described in Section 2.1.4 of this document), marked with pin flags containing the location ID, and recorded using a hand-held GPS unit.

At the time the tank berm investigations were conducted, Tank Berms 35, 36, 37, 38, 39 and 40 were located on privately owned property and considered “off-property”. CEMC has since purchased the property on which these tank berms are located and they will be considered “on-property” when evaluating future actions. Property ownership does not affect the Facility boundary. The prior owner had used that area for grazing and farming purposes and continues to do so under a term lease with CEMC. These tank berms have been disturbed by those activities to the extent that original contours are no longer discernible. The same is true for Tank Berm 34, which also experienced disturbance (i.e., excavation) related to work completed under the VCP and construction of a nearby residence. Additional disturbance occurred within the former Tank Berm 34 area during interim actions to remediate residential soils impacted with elevated levels of lead. These interim actions are discussed in more detail in Section 3.10 and Chapter 8.0.

For these “disturbed” tank berms, determination of soil boring locations could not be made based solely on field observations. Boring locations were therefore selected in the following manner:

- Locations were identified using historical aerial photos showing the berms and tank footprints.
- These points were marked within GIS and coordinate data uploaded to a GPS unit for location.
- Field crews sited direct push locations, by GPS, for Tank Berms 34, 35, 36, 37, 38, 39, and 40.
- On the ground, field crews were sometimes able to identify faint partial outlines of tank berm or footprint areas. The features that could be identified were used to adjust locations as necessary, provided there was sufficient evidence to do so.

Boring location IDs were assigned following the same procedures used for the “undisturbed” tank berms. Wooden stakes with location IDs were placed at the selected locations in lieu of pin flags due to the presence of cattle in the field.

On average, 12 – 18 borings were installed in each tank berm, the exact number dependent upon the size of the tank berm, field screening data, and personnel observations. Borings were screened at 2-foot intervals using XRF and PID/FID units. Samples were collected from 4 – 7 borings, on average, in each tank berm. Borings selected for sampling were based upon field screening data, field conditions, and personnel observations, with focus on borings exhibiting impacts. Impacts were defined as XRF screenings of > 400 ppm Pb, elevated PID/FID readings, observed hydrocarbon staining or odors, and observed debris. Note that in some instances, hydrocarbon impacts (visual or olfactory evidence) were noted in soil cores without the presence of elevated PID/FID readings; in these instances, field staff selected those intervals for sample collection. Samples were also collected from 2 – 4 borings located in the former tank footprint and upslope areas of the tank berm. If no borings exhibited impacts, those selected for sampling were based on spatial distribution, representing the four quadrants of the tank berm and the former tank footprint. Figures 3-1 and 3-2 depict tank berm subsurface boring locations.

Borings selected for sampling were sampled at three different intervals, selected to represent both surface (0-2 ft-bgs) and subsurface (>2 ft-bgs) conditions. Selected borings were sampled at 0-6 in-bgs and 18-24 in-bgs. In addition, a sample was collected from either the 2-3.33 ft-bgs interval or the 4.66-6 ft-bgs interval, alternating these intervals between borings. If a boring exhibited impacts, a sample was collected from the most impacted interval, regardless of where that interval occurred. The exception to this sampling protocol occurred when borings exhibited no impacts until refusal depth had been reached (or almost reached). In such cases, impacts (usually in the form of elevated PID/FID readings) were deemed to be the result of “smear zone” contamination, i.e., contamination due to fluctuating levels of contaminated groundwater, and not a surface or subsurface soil source.

Analyses conducted were based on the depth interval from which soil was collected (analytical method number in parentheses):

- 0-6 in-bgs interval – Pb, Metals (6010), Tetraethyl lead (8270), As (6020), Hg (7471), Total Cyanide (9012A), SVOCs (8270), total EPH (MT-EPH)
- 18-24 in-bgs interval – VOCs (8260), total VPH (MT-VPH)
- 2-3.33 ft-bgs or 4.66-6 ft-bgs intervals – all COI list constituents
- Intervals exhibiting impacts – all COI list constituents

The combined constituents analyzed at the 0-6 in-bgs and 18-24 in-bgs intervals represent all COI list constituents. Samples were given the same ID as the boring locations, using the naming convention described in Section 2.1.4.

Previously Reported Results

The process used to evaluate tank berm subsurface soil data was the same as described in Section 2.3.1 of this document and is further detailed in Section 3.2.4 of the CSM Update Report. Results reported in this document use only residential screening levels.

Previously reported conclusions presented in the CSM Update Report include the following:

- As with tank berm surface soils, the nature of soil impacts in the former tank berms is consistent with the historical use as a tank farm for storage of hydrocarbon. The primary constituents detected include hydrocarbon fractions, hydrocarbon-related VOCs and SVOCs, and lead.
- Subsurface locations of elevated lead occur in Tank Berms 3, 18, and 30, and at one location in Tank Berm 5. These correspond with surface lead impacts in those same tank berms. The elevated lead concentrations were only detected at depths shallower than 5 ft-bgs. The lead impacts are fairly localized and well defined using a combination of field and analytical data. The lead impacts do not correspond with elevated concentration of hydrocarbon constituents in Tank Berms 3, 15, and 18, but may be associated with hydrocarbon in Tank Berms 30 and 32. Tetraethyl lead was not detected in any soil samples. Limited additional sampling may be required to delineate the lead impacted areas.
- Fifteen of the tank berms had detections of hydrocarbon-related constituents in the subsurface, at depth >2 ft-bgs. For most of these areas, the detected concentrations exceeded the subsurface RBSL by less than a factor of 10. These locations may be addressed in the site-specific risk assessment. Subsurface samples from Tank Berms 5, 7, 18, 25, and 30 exceeded the RBSL for a VPH and/or EPH fraction(s) by more than a factor of 10. Additional investigation may be warranted to target these areas to evaluate if they represent continuing sources for groundwater impacts.

Activities to address additional delineation, based on the above recommendations, were detailed in the Phase II RI Work Plan and are summarized in the following section of this document.

3.1.2.2 STEP-OUT AND/OR DELINEATION SAMPLING

Section 2.2.2 of the Phase II RI Work Plan discussed proposed sampling activities to further delineate tank berm soils. The proposed investigations were based on the information presented in the CSM Update Report and the addendum to the CSM Update Report. As summarized in those documents, Pb, VPH, EPH, and petroleum hydrocarbon-related VOCs and SVOCs were the primary constituents that exceeded RBSLs in surface and/or subsurface soil in the tank berm areas. The proposed investigation activities were also based on discussions with MDEQ during a meeting on June 17, 2010, the outcome of which is summarized in Section 3.1.1.2.

As with surface soil delineation, proposed subsurface soil delineation locations were presented on Figures 2.2-1 and 2.2-2 of the Phase II RI Work Plan. The rationale for those locations was presented in Tables 2.2-2 and 2.2-3 of that same document. Subsurface soil delineation activities were conducted in August 2010, following the procedures described Section 2.1.1 of this document, including screening/sampling four surface soil intervals as opposed to the five intervals utilized during the initial investigation. During review and finalization of the Phase II RI Work Plan, MDEQ indicated the 0-2 in-bgs and 2-6 in-bgs intervals could be combined into one 0-6 in-bgs interval, for future surface soil screening/sampling activities, thereby reducing the number of intervals from five to the four as described in Section 2.1.

As discussed above, Tables 3-1 and 3-2 of this document present a correlation between the IDs for the initial or parent locations and their corresponding step-out or delineation locations. The naming convention used for location or sample IDs is discussed in Section 2.1.4 and presented in Table 2.1-3. Note that sample prefixes may have changed between parent and step-out locations. For example, initial samples collected from tank berms utilized the prefix "TB". However, corresponding step-out locations more often than not utilize the prefix "TF". Many of the proposed step-out sample locations associated with tank berms were located outside of the berm itself. Therefore the tank farm or "TF" prefix was used in the sample naming convention. Tables 3-1 and 3-2 provide the link between parent and step-out samples.

3.1.3 DEVIATIONS FROM WORK PLAN

Deviations from the Phase II RI work plan during initial tank berm surface soil and subsurface soil investigations are discussed in detail in Sections 3.1.2 and 3.2.2 of the CSM Update Report. The more notable deviations are discussed in the following subsections.

3.1.3.1 SURFACE SOILS

Tank Berms 13 and 29 were not sampled during the 2009 - 2010 tank berm surface soil investigations. At the time of the initial investigations, the footprint of Tank Berm 13 was partially located under the soil pile managed on property as investigation-derived debris. It was subsequently sampled as part of the investigation program discussed in Section 3.6 of this Report. Tank Berm 29 was previously excavated, and all associated material was placed in the constructed stabilized waste landfill that occupies that former tank berm location.

XRF screening of surface soils and confirmation sampling were conducted in the southern portion of Tank Berm 34 only, as prior remediation work in the northern portion included the excavation and removal of lead-impacted soils.

3.1.3.2 SUBSURFACE SOILS

As with the surface soil investigation, Tank Berms 13 and 29, and the northern portion of Tank Berm 34, were not included in the initial subsurface soil investigation. At the time of the initial subsurface soil investigation in late 2009, residential soils excavated during prior interim actions to address lead-impacted soils (see discussion in Section 3.10) were stockpiled in the area partially occupied by Tank Berm 13. Those soils were later moved and covered, and are being managed pending a final corrective action (to be determined by MDEQ). The subsurface of Tank Berm 13 was eventually sampled in the same manner as other tank berms, as discussed in Section 3.6. Tank Berm 29 was previously excavated, and all associated material was placed in the constructed stabilized waste landfill that occupies that former tank berm location. At Tank Berm 34, prior remediation activities involving excavation of impacted soils and backfill with clean soils had been performed in the northern portion of Tank Berm 34 (see discussion in Section 3.10). The subsurface of the southern portion of Tank Berm 34 was investigated in the same manner as other tank berms, as discussed in Section 3.6.

3.1.4 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

3.1.4.1 SURFACE SOILS

A total of 1,311 samples consisting of 1,011 environmental samples, 101 blind duplicates, 78 equipment blanks, and 121 trip blanks, were collected between September 2009 and November 2011. This collection effort resulted in approximately 60,331 sample results including: 43,179 environmental sample results, 4,781 field duplicate sample results, 7,291 equipment blank sample results, and 5,080 trip blank sample results. The results were reported in 166 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the method detection limit (MDL) but less than the reporting limit (RL). Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 2,302 data points were qualified as J by the laboratory. Out of these laboratory J flags, 1,965 were preserved during the Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	5,010
UJ	3,659
JB	269
R	244
TOTAL	9,182

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

Quality control sample submittal requirements specified in the QAPP were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	121	12%	10%*
Equipment Blanks	78	8%	5%
Blind Duplicates	101	10%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 47,960 environmental and field duplicate sample results reported and validated between September 2009 and August 2010, 241 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the surface soil sampling activities conducted during the tank berm investigation is 99.50%, which is greater than the required 90%.

3.1.4.2 SUBSURFACE SOILS

A total of 390 samples consisting of 224 environmental samples, 42 blind duplicates, 42 equipment blanks, and 82 trip blanks were collected between September 2009 and April 2011. This collection effort resulted in approximately 32,447 sample results including: 21,374 environmental sample results, 3,810 field duplicate sample results, 3,983 equipment blank sample results, and 3,280 trip blank sample results. The results were reported in 103 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. The laboratory also qualified data with J flags if the results were below the calibration range. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 968 data points were qualified as J by the laboratory. Out of these laboratory J flags, 755 were preserved during Tier III data validations.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	2,022
UJ	2,134
JB	91
R	89
TOTAL	4,336

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

Quality control sample submittal requirements specified in the QAPP were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	82	36.6%	10%*
Equipment Blanks	42	18.8%	5%
Blind Duplicates	42	18.8%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 25,184 environmental and field duplicate sample results reported and validated between September 2009 and April 2011, 87 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the subsurface soil sampling activities conducted in the tank berm investigation is 99.66%, which is greater than the required 90%.

3.1.5 RESULTS

In this section, the tank berm soil sampling program refers to samples with “TB” prefixes. Nearly all of these samples were collected within the former tank berms in 2009 and 2010, and the results were presented in the CSM Update and CSM Update Addendum.

Overall, the tank berm sampling program included collection and laboratory analysis of 678 surface soil samples and 214 subsurface soil samples. As proposed in the Phase II RI Work Plan, additional samples were collected between August 2010 and November 2011 to delineate the extent of soil screening criteria exceedances. These remaining (delineation) samples were collected outside of tank berms and are described in the section titled “Tank Farm”. Nine subsequent samples (all from the subsurface at Tank Berm 13) had “TB” prefixes. These samples were collected to serve as verification samples for one of the VCP excavations. However, because they were collected within the footprint area of Tank Berm 13, they are presented here along with the tank berm results. The remaining results of VCP excavation verification samples are presented in Section 3.6.

Figures 3-1 and 3-2 show the locations of the 40 former tank berms, as well as the surface sample and subsurface sample locations, respectively. Figures 3-1 and 3-2 serve as keys to the surface data summary maps (Figures 3-3A and 3-3B) and the subsurface data summary maps (Figures 3-4A and 3-4B). The data summary maps show the locations from which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In addition, Figures 3-3A/3B and 3-4A/4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation Approach

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.1-1 and 3.1-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Overall, the tank berm sampling program included collection of 678 surface samples for laboratory analysis in 2009 and 2010. Those samples are designated with “TB” prefixes. Figures 3-3A and 3-3B and Table 3.1-1 summarize the

analytical results for the surface soil samples. Analytical results for the TB- surface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A; samples IDs are listed alphabetically.

The TB- surface soil data set, in its entirety, was previously presented in the CSM Update Addendum. However, due to the use of updated screening criteria, the summary information presented in Table 3.1-1 differs slightly from that presented in the CSM Update Addendum summary tables.

Nineteen VOCs, twenty-two SVOCs, and all six hydrocarbon fractions were detected in at least one sample. Toluene (8% of the samples), benzene (6%), and total xylenes (6%) were the most frequently detected VOCs. The most frequently detected SVOCs were PAHs including benzo(a)pyrene (14%), chrysene (7%), dibenz(a,h)anthracene (8%) and pyrene (6%). The hydrocarbon fractions detected with the greatest frequency were (C11-C22 aromatic [19%] and C19-C36 aliphatic [21%]).

Direct Contact Screening Evaluation

Constituents in the TB- surface soil samples exceeding the residential direct contact SLs consisted of the following:

- VOCs:
 - Ethylbenzene (2 of 392 samples [$<1\%$ of the samples])
 - 1,2,4-Trimethylbenzene (3 of 392 samples [$<1\%$ of the samples])
 - 1,3,5-Trimethylbenzene (1 of 392 samples [$<1\%$ of the samples])
 - Xylenes [m,p-, o-, and total] (3 of 392 samples [$<1\%$ of the samples])
- SVOCs:
 - Benzo(a)anthracene (4 of 394 samples [1% of the samples])
 - Benzo(a)pyrene (24 of 394 samples [6% of the samples])
 - Benzo(b)fluoranthene (4 of 394 samples [1% of the samples])
 - Dibenz(a,h)anthracene (9 of 394 samples [2% of the samples])
 - Indeno(1,2,3-cd)pyrene (1 of 394 samples [$<1\%$ of the samples])
- Carbon Fractions:
 - C5-C8 aliphatic (3 of 391 samples [$<1\%$ of the samples])
 - C9-C10 aromatic (3 of 391 samples [$<1\%$ of the samples])

- C9-C12 aliphatic (3 of 391 samples [$<1\%$ of the samples])
- C11-C22 aromatic (6 of 87 samples [7% of the samples])
- Inorganics:
 - Antimony (2 of 678 samples [$<1\%$ of the samples])
 - Copper (1 of 678 samples [$<1\%$ of the samples])
 - Lead (31 of 678 samples [5% of the samples])
 - Mercury (1 of 647 samples [$<1\%$ of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figures 3-3A and 3-3B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the TB- surface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (1 of 392 samples [$<1\%$ of the samples])
 - n-Butylbenzene (2 of 392 samples [$<1\%$ of the samples])
 - sec-Butylbenzene (2 of 392 samples [1% of the samples])
 - Ethylbenzene (1 of 392 samples [$<1\%$ of the samples])
- SVOCs:
 - Benzo(a)pyrene (1 of 394 samples [$<1\%$ of the samples])
 - 1-Methylnaphthalene (8 of 394 samples [2% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figures 3-3A and 3-3B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3).

Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (678 of 678 samples [100% of the samples])
- Arsenic (4 of 671 samples [<1% of the samples])
- Barium (39 of 678 samples [6% of the samples])
- Beryllium (232 of 678 samples [34% of the samples])
- Cadmium (113 of 678 samples [17% of the samples])
- Chromium (42 of 678 samples [6% of the samples])
- Cobalt (25 of 678 samples [4% of the samples])
- Copper (16 of 678 samples [2% of the samples])
- Lead (194 of 678 samples [29% of the samples])
- Mercury (25 of 678 samples [4% of the samples])
- Nickel (7 of 678 samples [1% of the samples])
- Selenium (32 of 678 samples [5% of the samples])
- Silver (678 of 678 samples [100% of the samples])
- Vanadium (123 of 678 samples [18% of the samples])
- Zinc (12 of 678 samples [2% of the samples])

Delineation Evaluation

Section 3.4.4 of the CSM Update Addendum indicated that lead impacted surface soil had been identified in Tank Berms 3, 15, 18, 30, and 32. Subsequent sampling conducted pursuant to the Phase II RI Work Plan was designed, in part, to delineate these impacts. Table 2.2-2 of the Phase II RI Work Plan described the program for delineation of lead impacts in soil. As shown on Figures 3-3A and 3-3B the lead surface soil impacts in these tank berm areas have been delineated.

Section 3.4.4 of the CSM Update Addendum identified surface soil impacted with petroleum hydrocarbons, SVOCs, and/or VOCs in the following tank berms: 3, 5, 7, 10, 11, 12, 17, 18, 21, 25, 27, 28, 30, 31, and 36. The Phase II RI

soil sampling program was designed, in part, to delineate these impacts. Table 2.2-3 of the Phase II RI Work Plan described the program for delineation of the hydrocarbon surface soil impacts identified in the tank berm areas. As shown on Figures 3-3A and 3-3B, the surface soil impacts (hydrocarbons and hydrocarbon constituents) in these tank berm areas have been generally delineated. Additional delineation may be considered during scoping of remedial activities in the following locations:

- To the northeast of TB03-E02-SS01
- To the northwest of TF-G12-SS01
- To the northeast of TFS1-G11-SS01
- To the south and east of TFS1-L10-SS01
- To the south and east of TB27-E05-DP01
- To the north and northwest of TB31-D02-DP01
- To the northwest of TFS1-A03-SS01

Section 3.4 of the CSM Update presented a list of tank berms where hydrocarbon constituent concentrations were below screening criteria. Based on application of a moisture correction to soil concentration data (see discussion in Section 2.1.5), surface soil concentrations of benzo(b)fluoranthene and benzo(a)pyrene slightly exceed the screening criteria in three samples from Tank Berm 34 (Figure 3-3A).

Subsurface Soil Results

The tank berm sampling program also included collection of 214 subsurface soil samples for laboratory analysis. Those samples are designated with “TB” prefixes. Figure 3-2 shows the subsurface soil sample locations for the tank berm program and serves as a key to Figures 3-4A and 3-4B, which summarize the analytical results for the subsurface soil samples. Tabular data summaries are presented in Table 3.1-2. Analytical results for the TB- samples are tabulated along with the other project soil data in Appendix 3-A; samples are listed alphabetically by sample ID.

Eighteen petroleum hydrocarbon VOCs and twenty petroleum hydrocarbon SVOCs were detected in one or more subsurface soil samples. The constituents xylenes (13% of the samples), 1,2,4-trimethylbenzene (12%), 1,3,5-trimethylbenzene (10%), toluene (10%) and sec-butylbenzene (10%) were the VOCs detected with the highest frequency. Phenanthrene (10%), 1-methylnaphthalene (9%), 2-methylnaphthalene (9%), and benzo(a)pyrene (9%) were the most frequently detected PAHs. The six hydrocarbon fractions were all detected at similar frequencies (10% - 15%).

Direct Contact Screening Evaluation

Constituents in the TB- subsurface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs:
 - 1,2,4-Trimethylbenzene (8 of 214 samples [4% of the samples])
 - 1,3,5-Trimethylbenzene (1 of 214 samples [<1% of the samples])
 - Xylenes [m,p-, o-, and total] (4 of 214 samples [2% of the samples])
- SVOCs:
 - Benzo(a)pyrene (1 of 214 samples [<1% of the samples])
 - 1-Methylnaphthalene (3 of 214 samples [1% of the samples])
 - 2-Methylnaphthalene (4 of 214 samples [2% of the samples])
- Carbon Fractions:
 - C5-C8 aliphatic (3 of 214 samples [1% of the samples])
 - C9-C10 aromatic (3 of 214 samples [1% of the samples])
 - C9-C12 aliphatic (3 of 214 samples [1% of the samples])
 - C9-C18 aliphatic (6 of 43 samples [14% of the samples])
 - C11-C22 aromatic (3 of 43 samples [7% of the samples])
- Inorganics:
 - Antimony (5 of 214 samples [2% of the samples])
 - Lead (6 of 214 samples [3% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figures 3-4A and 3-4B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the TB- subsurface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (7 of 214 samples [3% of the samples])
 - Ethylbenzene (2 of 214 samples [<1% of the samples])
- SVOCs:
 - Benzo(a)anthracene (1 of 214 samples [[<1% of the samples])
 - Benzo(a)pyrene (1 of 214 samples [<1% of the samples])
 - 1-Methylnaphthalene (19 of 214 samples [9% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figures 3-4A and 3-4B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (214 of 214 samples [100% of the samples])
- Arsenic (4 of 214 samples [2% of the samples])
- Barium (6 of 214 samples [3% of the samples])
- Beryllium (59 of 214 samples [28% of the samples])
- Cadmium (9 of 214 samples [4% of the samples])
- Chromium (14 of 214 samples [7% of the samples])
- Cobalt (27 of 214 samples [13% of the samples])
- Copper (7 of 214 samples [3% of the samples])
- Lead (14 of 214 samples [7% of the samples])
- Mercury (8 of 214 samples [4% of the samples])
- Nickel (9 of 214 samples [4% of the samples])
- Selenium (3 of 214 samples [1% of the samples])
- Silver (214 of 214 samples [100% of the samples])



- Vanadium (26 of 214 samples [12% of the samples])
- Zinc (4 of 214 samples [2% of the samples])

Delineation Evaluation

Based on the CSM Update Report (e.g., Figure 3.2-1 of that report), subsurface lead impacts were identified in Tank Berms 3, 5, 18, and 30. Table 2.2-2 of the Phase II RI Work Plan described the program for delineation of lead impacts that were identified in the CSM Update Report. No additional samples were required for lead delineation. As shown on Figures 3-4A and 3-4B the lead subsurface soil impacts in these tank berm areas have been delineated based on analytical and XRF soil screening results. Additional delineation for lead may be considered during scoping of remedial activities in the following location:

- To the northeast of TB30-D02-DP01

The Phase II RI soil sampling program was designed, in part, to delineate subsurface hydrocarbon impacts. Table 2.2-3 of the Phase II RI Work Plan describes the program for delineation of the subsurface soil impacts identified in the tank berm areas. Based on CSM Update Addendum (Table 2.2-3) and Figure 3.4-2 and 3.4-3 of the CSM Update, additional delineation of subsurface hydrocarbon impacts was performed at the following tank berms: 2, 5, 7, 10, 11, 15, 18, 27, 30, and 31. As shown on Figures 3-4A and 3-4B, the subsurface soil impacts (hydrocarbons and hydrocarbon constituents) in these tank berm areas have been delineated. The following should be noted:

- At Tank Berm 2, subsurface impacts may be continuous with those in pipeline corridor to west.
- At Tank Berm 5, additional delineation of subsurface impacts may be considered to the north.
- At Tank Berm 10, additional delineation may be considered to the northwest of TB10-C04-DP01.
- At Tank Berm 15, additional delineation may be considered to the southwest of TB15-E04-DP01.
- At Tank Berm 18, additional delineation may be considered to the northwest of TB18-F02-DP02.
- At Tank Berm 31, the detection of antimony at TB31-BO3-DP01 is not delineated.

Additional delineation of impacts in the areas identified above may be considered/conducted during scoping of remedial activities.

Section 3.4 of the CSM Update presented a list of tank berms where hydrocarbon constituent concentrations were below screening criteria. Based on application of a moisture correction to soil concentration data (see discussion in Section 2.1.5), subsurface soil concentrations of some constituents exceed the current screening criteria in some samples from Tank Berm 2, Tank Berm 9, Tank Berm 23, and Tank Berm 26 (Figure 3-4A and Figure 3-4B). The low

levels of subsurface hydrocarbon impacts identified at Tank Berm 2, Tank Berm 9, and Tank Berm 23 appear to be adequately delineated. Additional delineation of the C9-C10 aromatic hydrocarbon fraction (107 mg/kg versus (vs) screening criteria of 100 mg/kg) at Tank Berm 26 (location ID TB-26-E03-DP01) may be considered during scoping of remedial activities.

3.2 TANK FARM AREA

Tank farm soils are defined as those soils located within the former tank farm area, but not contained within the footprint of former tank berms. Tank farm soils were investigated in accordance with the sampling plans and procedures outlined in the CSM Work Plan. That work was completed in February 2010 and is discussed in detail, along with resulting data, in the CSM Update Addendum. Additional surface soil sampling for lead was conducted in tank farm grids F04, F07, M07, G12, M12, N12, Q09, Q10, Q11, and Q12 during the 2010-2011 field seasons.

3.2.1 INVESTIGATION METHODS

Tank farm soil investigation methods involved a combination of screening for metals using portable XRF units and laboratory analysis for a percentage of those screenings, as described in Section 2.1.1. Samples collected for laboratory analysis were analyzed for metals to confirm XRF screening results. Additionally, a portion of the samples were analyzed for the remaining constituents on the Facility COI list, in accordance with MDEQ's September 22, 2009 correspondence (MDEQ 2009b).

3.2.1.1 INITIAL INVESTIGATION

Initial step-out locations were based on the proposed locations shown on Figure 2.2-1 of the Phase II RI Work Plan. The sample locations were selected to delineate previous locations where samples exceeded the USEPA residential RSL for lead. Proposed locations were placed using a 50 foot grid cell pattern with the parent location being placed in the center cell. If a previously sampled location fell within one of the surrounding cells, a delineation sample was not collected from that cell.

Borings were installed using a direct push device to a depth of 2 ft-bgs at the locations shown on Figure 3-1. Sample intervals (0-6 inch, 6-12 inch, 12-18 inch, 18-24 inch) were field screened with an XRF. Laboratory confirmation sampling was conducted on 10 percent of the screened intervals, according to the criteria used in the previous phase of investigation. Samples submitted to lab were analyzed for lead (6010).

3.2.1.2 STEP-OUT AND/OR DELINEATION SAMPLING

Results from the samples sent to the laboratory for analyses were reviewed prior to selecting the additional delineation locations. The second set of delineation samples were collected, when necessary, to delineate the extent of lead impacts above the USEPA residential RSL of 400 mg/kg.

The second step-out group was conducted similarly to the first generation of delineation sampling. Sample locations were selected by creating a 50 foot grid cell pattern with the parent location being placed in the center cell. If a previously sampled location fell within one of the surrounding cells a delineation sample was omitted from that cell and no second generation step-out sampling was conducted. Boring installation, screening and sample collection were conducted the same as the method used during the initial sampling task. Locations are shown on Figure 3-1.

3.2.2 DEVIATIONS FROM WORK PLAN

Deviations from the work plan for the tank farm delineation sampling were limited. Sampling and screening protocol were followed per the FSP and methods used from the initial tank farm sampling. Proposed step-out locations were adjusted, within their grid cell, due to observations made in the field. Observations that would warrant a change in the proposed location would be nearby utilities, public road surface, or unsafe work location. The second step-out locations were also adjusted if there was an elevated concentration of lead observed with the XRF. In such cases, the first location was discarded and another location was selected further out from the impacted location, in an attempt to bound the impacted areas with unimpacted locations.

3.2.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 141 samples consisting of 105 environmental samples, 17 blind duplicates, 9 equipment blanks, and 10 trip blanks, were collected between January 2010 and November 2011. This collection effort resulted in approximately 5,164 sample results including: 3,417 environmental sample results, 602 field duplicate sample results, 745 equipment blank sample results, and 400 trip blank sample results. The results were reported in 26 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the data validation review, laboratory J flags were preserved in the data. A

total of 331 data points were qualified as J by the laboratory. Out of these laboratory J flags, 304 were preserved during Tier III data validations. The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	665
UJ	101
JB	30
R	1
TOTAL	797

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

Quality control sample submittal requirements specified in the QAPP were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	10	9.5%	1 per cooler*
Equipment Blanks	9	8.6%	5%
Blind Duplicates	17	16.2%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 4,019 environmental and field duplicate sample results reported and validated between January 2010 and November 2011, one was rejected as a result of this data validation review. The completeness measure for the data generated for the soil sampling activities in tank farm investigation is 99.98%, which is greater than the required 90%.

3.2.4 RESULTS

In this section, the tank farm soil sampling program refers to samples with “TF” prefixes. Most of these samples were collected within the tank farm (outside of the former tank berms) in 2009 and 2010, and the results were presented in the CSM Update and CSM Update Addendum. Additional samples were collected in 2010 and 2011 to delineate areas of soil impacts that had been identified in the Phase II RI Work Plan.

Overall, the tank berm sampling program included collection and laboratory analysis of up to 84 surface soil samples (lead) and 14 subsurface soil samples (VOCs and VPH). As proposed in the Phase II RI Work Plan, additional samples were collected between August 2010 and November 2011 to delineate the extent of soil screening criteria exceedances. The analyte list for the delineation samples was dependent upon the nature of impacts being delineated. As a result, the sample counts in Table 3.2-1 and Table 3.2-2 vary by analyte.

Figures 3-1 and 3-2 show the locations of the former tank farm area, as well as the surface sample and subsurface sample locations, respectively. Tank farm soil sample IDs corresponded to the site grid, which is also shown on Figures 3-1 and 3-2. Figures 3-1 and 3-2 serve as keys to the surface data summary maps (Figures 3-3A and -3B) and the subsurface data summary maps (Figures 3-4A and -4B). The data summary maps show the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In addition, Figures 3-3A/3B and 3-4A/4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation Approach

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.2-1 and 3.2-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Some of the TF- surface soil data was previously presented in the CSM Update Addendum. However, due to the use of updated screening criteria, the summary information presented in Table 3.2-1 differs slightly from that presented in the CSM Update Addendum summary tables.

Four VOCs, seventeen SVOCs, and four hydrocarbon fractions were detected in at least one sample. The PAHs benzo(a)pyrene (21 samples), benzo(b)fluoranthene (16), chrysene (16), pyrene (16), and phenanthrene (11) were the most frequently detected constituents. The hydrocarbon fractions detected with the greatest frequency were C11-C22 aromatic (14) and C19-C36 aliphatic (14).

Direct Contact Screening Evaluation

Constituents in the TF- surface soil samples exceeding the direct contact SLs consisted of the following:



- VOCs: None
- SVOCs:
 - Benzo(a)pyrene (8 of 51 samples [16% of the samples])
 - Benzo(b)fluoranthene (3 of 51 samples [6% of the samples])
- Carbon Fractions:
 - C11-C22 aromatic (1 of 15 samples [7% of the samples])
- Inorganics:
 - Lead (10 of 84 samples [12% of the samples])
 - Mercury (1 of 50 samples [2% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figures 3-3A and 3-3B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the TF- surface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs: None
- SVOCs:
 - 1-methylnaphthalene (2 of 51 samples [4% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figures 3-3A and 3-3B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (50 of 50 samples [100% of the samples])
- Arsenic (0 of 50 samples [0% of the samples])



- Barium (6 of 50 samples [12% of the samples])
- Beryllium (28 of 50 samples [56% of the samples])
- Cadmium (18 of 50 samples [36% of the samples])
- Chromium (3 of 50 samples [6% of the samples])
- Cobalt (4 of 50 samples [8% of the samples])
- Copper (5 of 50 samples [10% of the samples])
- Lead (44 of 84 samples [53% of the samples])
- Mercury (9 of 50 samples [18% of the samples])
- Nickel (2 of 50 samples [4% of the samples])
- Selenium (15 of 50 samples [30% of the samples])
- Silver (50 of 50 samples [100% of the samples])
- Vanadium (17 of 50 samples [34% of the samples])
- Zinc (1 of 50 samples [2% of the samples])

Delineation Evaluation

Section 3.4.4 of the CSM Update Addendum indicated that lead impacted surface soil had been identified in nine tank farm grids (F04, F07, G12, M07, M12, N12, Q09, Q10, and Q11). Subsequent sampling conducted pursuant to the Phase II RI Work Plan was designed, in part, to delineate these impacts. Table 2.2-2 of the Phase II RI Work Plan described the program for delineation of lead impacts in soil. As shown on Figures 3-3A and 3-3B the lead surface soil impacts in these areas have been delineated.

Section 3.4.4 of the CSM Update Addendum also identified surface soil impacted with benzo(a)pyrene in the following tank farm grids: M07 and Q10. The Phase II RI soil sampling program was designed, in part, to delineate these impacts. Table 2.2-3 of the Phase II RI Work Plan described the program for delineation of the hydrocarbon surface soil impacts identified in the tank farm. As shown on Figures 3-3A and 3-3B, the surface soil impacts (benzo(a)pyrene) in these areas have been further delineated. Note that the extent of PAH impacts in grid Q10 may extend east into the railroad right-of-way.

Subsurface Soil Results

The tank farm sampling program also included collection of 14 subsurface soil samples for laboratory analysis of one or more COIs. The subsurface samples were collected in 2010 and 2011 as part of the delineation program described in the Phase II RI Work Plan. These samples are designated with and “TFS” prefixes. During collection of delineation samples in the tank farm in 2010 and 2011, the analyte list for each sample was determined based on the nature of impacts being delineated. As a result, sample counts in Table 3.2-2 vary between analyte groups. Figures 3-4A and 3-4B and Table 3.2-2 summarize the analytical results for the subsurface soil samples. Analytical results for the TFS-subsurface soil samples, as well as the other project subsurface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

Fourteen petroleum hydrocarbon VOCs were detected in one or more subsurface soil samples. The constituents 1,2,4-trimethylbenzene (2 samples; 17%), and n-butylbenzene (2 samples; 17%) were the VOCs detected with the highest frequency. The PAHs 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene were each detected in a single sample. The three hydrocarbon fractions C5-C8 aliphatic, C9-C10 aromatic, and C9-C12 aliphatic were detected in one, two, and one samples, respectively.

Direct Contact Screening Evaluation

There were no exceedances of direct contact screening levels in the subsurface TF- or TFS- subsurface soil samples.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the TF- subsurface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (1 of 12 samples [8% of the samples])
- SVOCs:
 - 1-Methylnaphthalene (1 of 14 samples [7% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figures 3-4A and 3-4B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3).

Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (1 of 1 samples [100% of the samples])
- Arsenic (0 of 1 samples [0% of the samples])
- Barium (0 of 1 samples [0% of the samples])
- Beryllium (0 of 1 samples [0% of the samples])
- Cadmium (0 of 1 samples [0% of the samples])
- Chromium (0 of 1 samples [0% of the samples])
- Cobalt (0 of 1 samples [0% of the samples])
- Copper (0 of 1 samples [0% of the samples])
- Lead (0 of 1 samples [0% of the samples])
- Mercury (0 of 1 samples [0% of the samples])
- Nickel (0 of 1 samples [0% of the samples])
- Selenium (0 of 1 samples [0% of the samples])
- Silver (0 of 1 samples [0% of the samples])
- Vanadium (0 of 1 samples [0% of the samples])
- Zinc (0 of 1 samples [0% of the samples])

Delineation Evaluation

The subsurface “TFS” samples were collected to delineate impacts identified in the June 2010 addendum to the CSM Update Report. Table 2.2-3 of the Phase II RI Work Plan, which describes the program for delineation of the surface soil impacts, resulted in collection of subsurface samples (“TFS” samples) in grids F09, F11, G10, G12, H07, H08, I08, I11, J10, J11, K09, M08, M11, and N15. As shown on Figures 3-4A and 3-4B, the subsurface soil impacts (hydrocarbons and hydrocarbon constituents) in these areas have been generally delineated, as noted in Section 3.1.

The following should be noted:

- At Tank Berm 2, subsurface impacts identified at TFS-H07-DP01 and TB02-B05-DP02 may be continuous with those identified in the pipeline corridor to the south and west of Tank Berm 2.

3.3 ASPHALT, SLAG, CINDER AREAS

During Phase II RI field activities, a total of eleven asphalt, slag, cinder areas (ASCs) were identified and sampled. Ten of the eleven areas contained elevated concentrations of constituents from the Facility COI list (either lead, one or more SVOCs, or EPH. This information was presented to MDEQ during the October 7, 2010 meeting. ASC06 was the only area that did not contain constituents at concentrations above screening levels.

3.3.1 INVESTIGATION METHODS

Investigation activities were conducted in accordance with the approved Phase II RI Work Plan. Samples associated with the ASC investigation activities were collected and analyzed in accordance with the procedures defined in the FSP and QAPP. Deviations from the approved documents are discussed in Section 3.3.2.

3.3.1.1 INITIAL INVESTIGATION

Eleven ASC areas were identified, spatially delineated through visual inspection of the ground surface (with perimeter defined using a hand-held GPS), and sampled during Phase II RI field activities. Field teams collected five-point composite samples from each ASC area. The five locations of the composite sample were spatially distributed and based upon visual indicators at the surface such as staining, and/or presence of asphalt, slag or cinder being present. Each location was flagged and documented using a hand-held GPS by the field team. An aliquot of soil was collected from 0-2 ft-bgs at each of the five points comprising the composite sample. Soil from the 1.5-2 ft-bgs interval at each of the five points was individually jarred for VOC/VPH analyses. Soil from 0-0.5 ft-bgs interval of each of the five locations was composited and a single sample was collected. That composite sample was analyzed for the following constituents (analytical method in parentheses): lead (6010), metals (6010), arsenic (6020), mercury (7471), SVOCs (8270), MT-EPH and asbestos. Asbestos was added to the Facility soil COI list for the ASC areas in response to MDEQ comments on the Phase II RI Work Plan. In those comments, dated May 14, 2010 (see Appendix 1-A), MDEQ indicated sampling for asbestos should be conducted from any surface soil (0-2 ft-bgs) interval exhibiting visual evidence of asbestos impacts. In the absence of visual evidence, samples from different six-inch intervals within the 0-2 ft-bgs core were to be submitted for asbestos analysis.

3.3.1.2 STEP-OUT AND/OR DELINEATION SAMPLING

Ten of the eleven ASC areas sampled contained constituents that exceeded the MDEQ-RBSL. ASC06 was the only area that did not contain constituents at concentrations above screening levels. Delineation sampling was conducted at ASC areas 01-05 and areas 07-11. Locations were selected for delineation sampling by creating a 20 foot buffer around the boundary of the ASC area. Locations were then placed along the buffer line at an approximate 50-foot spacing.

Samples were collected from each delineation location with two intervals being collected from 0-2 ft-bgs. Soil from the 0-0.5 ft-bgs interval was collected and analyzed for the following constituents (analytical method in parentheses): SVOCs (8270), TEL (8270), metals (6010), lead (6010), arsenic (6020), mercury (7471), cyanide (9012A), and MT-EPH. Soil from the 1.5-2 ft-bgs interval was collected and analyzed for the following constituents: VOCs (8260) and MT-VPH. Asbestos was not detected during the initial investigation and was therefore eliminated from the list of constituents analyzed.

3.3.2 DEVIATIONS FROM WORK PLAN

Two deviations from the work plan during the course of the investigation are noted. The work plan indicated that a 50'x50' grid system would be established, should an area be greater than 2,500 ft². ASC10 has an area slightly larger than 2,500 ft², but a 50'x 50' grid system was not established over this area. It was determined that since the area of ASC10 was 2,521 ft² only one composite sample would be collected and the laboratory data from this one sample would be analyzed to determine if additional sampling would be needed. Laboratory data results showed elevated concentrations of some constituents from the composite sample, and as such, step-out sampling was conducted for ASC10.

At ASC11, one sample from the 1.5 - 2 ft-bgs interval contained constituents that exceeded the MDEQ RBSL. Therefore, in order to delineate the vertical extent of impacts, an additional soil boring was installed at this location to a depth of 4 ft-bgs, field screened, and a sample collected for laboratory analysis from the 3.5 – 4 ft-bgs interval. This sample was collected to determine the presence/absence of constituents exceeding MDEQ RBSLs at the deeper interval.

3.3.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 233 samples consisting of 174 environmental samples, 13 blind duplicates, 16 equipment blanks, and 30 trip blanks were collected between August 2010 and November 2011. This collection effort resulted in approximately 12,517 sample results including: 8,978 environmental sample results, 943 field duplicate sample results, 1,396 equipment blank sample results, and 1,200 trip blank sample results. The results were reported in 32 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. The laboratory also qualified data with J flags if the results were below the calibration range. Unless qualified for other reasons in the data validation review, laboratory J flags were preserved in the data. A total of 398 sample results were qualified as J by the laboratory. Out of these laboratory J flags, 256 were preserved during the Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	642
UJ	881
JB	100
R	231
TOTAL	1,854

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Analytical reports and electronic deliverables were complete. Quality control sample submittal met the requirements with the exception of blind duplicates that were not collected at the required frequency. However, these samples are part of a larger project in which field duplicate adequacy is met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	30	17.2%	1 per cooler*
Equipment Blanks	16	9.2%	5%
Blind Duplicates	13	7.5%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 9,921 environmental and field duplicate sample results reported and validated between August 2010 and November 2011, 230 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the sampling activities in the Asphalt, Slag and Cinder areas is 97.68%, which is greater than the required 90%.

3.3.4 RESULTS

Eleven ASC areas were identified and soil samples were collected from those areas between August 2010 and November 2011. Therefore, the results were not included in either the CSM Update or the CSM Update Addendum.

The ASC areas sampling program included collection and laboratory analysis of 64 surface soil samples analyzed for the full COI list and an additional 44 samples analyzed for the VOCs and VPH carbon fractions on the COI list. In addition, at ASC area 11, a subsurface soil sample was collected and analyzed for the full COI list.

Figures 3-1 and 3-2 show the locations of the eleven ASC areas, as well as the surface sample and subsurface sample locations, respectively. Figures 3-1 and 3-2 serve as keys to the surface data summary maps (Figures 3-3A and 3-3B) and the subsurface data summary maps (Figures 3-4A and 3-4B). The data summary maps show the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In addition, Figures 3-3A/3B and 3-4A/4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.3-1 and 3.3-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Figures 3-3A and 3-3B and Table 3.3-1 summarize the analytical results for the surface soil samples. Analytical results for the ASC surface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

In summary, sixteen VOCs, fourteen SVOCs, and all six hydrocarbon fractions were detected in at least one sample. Hexane (detected in 9% of the samples) was the most frequently detected VOC. The remaining detected VOCs each were reported in less than 4% of the samples. The most frequently detected SVOCs were PAHs: benzo(a)pyrene (48%), chrysene (36%), dibenz(a,h)anthracene (25%), indeno(1,2,3-cd)pyrene (31%), phenanthrene (25%), and pyrene (42%). The hydrocarbon fractions detected with the greatest frequency were the heavier end components: C11-C22 aromatic (53%) and C19-C36 aliphatic (59%).

Composite soil samples were collected from depths of 0 to 0.5 ft-bgs within each of the eleven ASC areas and submitted to EM Lab P&K for analysis of asbestos via USEPA Methods 600/M4-82-020 and 600/R-93-116. Asbestos fibers were not detected in any of the eleven samples. Asbestos sample results are provided in the laboratory reports within Appendix 3-D.

Direct Contact Screening Evaluation

Constituents in the ASC- surface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs: None
- SVOCs:
 - Benzo(a)anthracene (5 of 64 samples [8% of the samples])
 - Benzo(a)pyrene (20 of 64 samples [31% of the samples])
 - Benzo(b)fluoranthene 5 of 64 samples [8% of the samples])
 - Dibenz(a,h)anthracene (12 of 64 samples [19% of the samples])
 - Indeno(1,2,3-cd)pyrene (8 of 64 samples [13% of the samples])
- Carbon Fractions:
 - C9-C18 aliphatic (4 of 57 samples [6% of the samples])
 - C11-C22 aromatic (11 of 57 samples [17% of the samples])

- Inorganics:
 - Lead (2 of 64 samples [3% of the samples])
 - Mercury (2 of 64 samples [3% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figures 3-3A and 3-3B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the ASC- surface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs: None
- SVOCs:
 - Benzo(a)pyrene (1 of 64 samples [2% of the samples])
 - 1-Methylnaphthalene (2 of 64 samples [3% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figures 3-3A and 3-3B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (15 of 64 samples [23% of the samples])
- Arsenic (0 of 64 samples [0% of the samples])
- Barium (2 of 64 samples [3% of the samples])
- Beryllium (24 of 64 samples [38% of the samples])
- Cadmium (11 of 64 samples [17% of the samples])
- Chromium (4 of 64 samples [6% of the samples])
- Cobalt (5 of 64 samples [8% of the samples])

- Copper (9 of 64 samples [14% of the samples])
- Lead (33 of 64 samples [52% of the samples])
- Mercury (13 of 64 samples [20% of the samples])
- Nickel (1 of 64 samples [2% of the samples])
- Selenium (1 of 64 samples [2% of the samples])
- Silver (10 of 64 samples [16% of the samples])
- Vanadium (18 of 64 samples [28% of the samples])
- Zinc (5 of 64 samples [8% of the samples])

Subsurface Soil Results

The one ASC subsurface soil sample was collected from ASC area 11, which is located in the eastern portion of the project area (Figure 3-4B). Figure 3-4B summarizes the analytical results for the ASC subsurface soil sample as well as other subsurface soil samples collected in the surrounding area. Table 3.3-2 summarizes the ASC subsurface soil data. Detections of organic constituents were limited to the three EPH carbon fractions. Analytical results for the ASC sample, as well as the other project subsurface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

Direct Contact Screening Evaluation

The reported constituent concentrations in the subject sample met the direct contact SL. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The reported concentrations of the carcinogens in the subject sample met the MTGW SL.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (1 of 1 samples [100% of the samples])
- Arsenic (0 of 1 samples [0% of the samples])



- Barium (0 of 1 samples [0% of the samples])
- Beryllium (0 of 1 samples [0% of the samples])
- Cadmium (0 of 1 samples [0% of the samples])
- Chromium (0 of 1 samples [0% of the samples])
- Cobalt (0 of 1 samples [0% of the samples])
- Copper (0 of 1 samples [0% of the samples])
- Lead (0 of 1 samples [0% of the samples])
- Mercury (0 of 1 samples [0% of the samples])
- Nickel (0 of 1 samples [0% of the samples])
- Selenium (0 of 1 samples [0% of the samples])
- Silver (0 of 1 samples [0% of the samples])
- Vanadium (0 of 1 samples [0% of the samples])
- Zinc (0 of 1 samples [0% of the samples])

Geographic Evaluation

The ASC areas were identified via visual inspection and documented using a hand-held GPS unit. The purpose of the ASC soil sampling program was to determine whether the asphalt, slag, and cinder materials observed on the ground surface contained concentrations of constituents above the applicable SLs. With the exception of ASC 06, at least one sample from each area contained one or more constituents at a concentration above the applicable SL(s). The geographic extent of each ASC area was effectively documented via visual inspection; it is not expected that further delineation or characterization of these areas will be needed.

3.4 TANK BERM 34 DOWNWIND AREAS, HIGH SCHOOL, ELEMENTARY SCHOOL

Downwind residential areas addressed during CSM data collection activities consist of limited areas located downwind of Tank Berm 34. Additionally, CEMC screened soils located at the high school football field and elementary school children's play area. Both areas are located perpendicular to the prevalent wind direction, and thus are not directly downwind of the former refinery. However, these were identified as specific areas of interest by MDEQ. Therefore, 10 locations in each area were screened using XRF ex-situ screening procedures defined in the CSM Work Plan.

3.4.1 INVESTIGATION METHODS

Screening for lead by field XRF was performed at 20 locations along an arc approximately 450 feet from the center of Tank Berm 34 in possible downwind directions (NW to S). Five separate intervals (0-2 inches, 2-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches) from the top two feet of soil were field screened using the XRF. Based on the field screening results, five soil samples from the residence area northeast of Tank Berm 34 and five soil samples from southeast of Tank Berm 34 were submitted to the laboratory for lead analysis. Lead was detected in all laboratory samples at concentrations between 8.86 mg/kg and 105 mg/kg. These concentrations are below the MDEQ RMSL for lead (400 mg/kg).

In addition to the 20 locations along the arc, wind breaks, depositional areas, and erosional areas between the center of Tank Berm 34 and the approximate 450 feet arc were identified and investigated. The residential landscaping next to Tank Berm 34, fence lines to the north, east, and south, and the hedge across the street from residential property were either previously screened during the Tank Berm 34 excavation activities or were installed after the excavation. Therefore these wind breaks, depositional areas, or erosional areas had previously been addressed. Five wind break/depositional source areas (tall brush east of the residential property) within the arc were identified and field screened for lead using an XRF. The tall vegetation was removed and the bare soil surface was field screened using an XRF. Lead was detected in one of the five locations. Based on the field screening results, two complete COI list samples east of Tank Berm 34 were submitted to the laboratory for analysis.

Soil sample locations on the high school football field and the play area at the elementary school are presented on Figures 3-1 and 3.4-1. The analytical data are tabulated in Appendix 3-A; field documentation, including XRF field data, is presented in Appendix 3-B. Field screening by XRF was conducted at ten locations at both sites. Five separate intervals (0-2 inches, 2-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches) from the top two feet of soil were field screened using the XRF. Lead was not detected in any of the 100 field screened samples. Ten laboratory samples from each site were submitted for laboratory analysis of total lead. One sample from each school site was submitted for laboratory analysis of the complete COI list (Table 2.1-1). Additional soil screening and sampling was conducted on the elementary school play fields associated with the residential soil investigation (see Section 3.10).

3.4.2 DEVIATIONS FROM WORK PLAN

Field screening at the five wind break/depositional source areas, located between the center of Tank Berm 34 and the approximate 450 foot arc, were only field screened at the ground surface (0-2 inches). The four deeper screening intervals (2-6 inches, 6-12 inches, 12-18 inches, and 18-24 inches) were not screened by XRF. Two of the five screening locations were sampled and submitted for laboratory analysis from the 0-6 inch and 18-24 inches intervals.

No deviations from the work plan were noted for the 20 screening locations along an arc approximately 450 feet from the center of Tank Berm 34 in possible downwind directions (NW to S), the 10 high school football field screening locations, or the 10 elementary school play area screening locations.

3.4.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 89 samples, consisting of 60 environmental samples, 9 blind duplicates, 8 equipment blanks, and 12 trip blanks, were collected between November 2009 and November 2011. This collection effort resulted in an estimated total of 4,051 sample results including: 2,382 environmental sample results, 445 field duplicate sample results, 744 equipment blank sample results, and 480 trip blank sample results. The sample results were reported in 22 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the data validation review, laboratory J flags were preserved in the data. A total of 244 data points were qualified as J by the laboratory. Out of these laboratory J flags, 198 were preserved during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	446
UJ	126
JB	32
R	19
TOTAL	615

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal met the requirements specified in the QAPP. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	12	20.0%	1 per cooler*
Equipment Blanks	8	13.3%	5%
Blind Duplicates	9	15.0%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 2,826 environmental and field duplicate sample results reported and validated between November 2009 and November 2011, 19 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the sampling activities in Tank Berm 34, high school football field, and the elementary school playground is 99.33%, which is greater than the QAPP required 90%.

3.4.4 RESULTS

In this section, the soil sampling program pertaining to area downwind of Tank Berm 34 is specific to samples with “TB34-DW”, “HSFF”, and “ESPG” prefixes. Sampling events for this program were conducted iteratively to assess soils behind windbreaks (bushes, etc.) downwind of Tank Berm 34, as described in detail above. Based on the results of field screening, five surface soil samples were collected for laboratory analysis of the full COI list. An additional 16 samples were analyzed for the metals/metalloids on the COI list. The primary sampling event occurred in February 2010, with one additional sample collected in November 2011. The results of the February 2010 analyses were received after preparation of the CSM Update, but were included in the CSM Update Addendum. The previously reported results are included herein to facilitate understanding of conditions in the investigated area.

Figure 3-1 serves as a key to the various Phase II RI surface soil sampling programs discussed in this Report, and shows TB34-DW locations where surface soil samples were collected for laboratory analysis. Figure 3.4-1 depicts the locations at which Tank Berm 34 downwind soil samples were collected for laboratory analysis. In addition, Figure 3.4-1 shows locations where samples were collected for field XRF screening.

Data Evaluation

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed



in the summary data table (Table 3.4-1) and comprehensive data tables (Appendix 3-A). However, the data summary map focuses on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Figure 3.4-1 and Table 3.4-1 summarize the analytical results for the surface soil samples. A full report of the analytical results for surface soil samples from the Phase II RI projects is provided in Appendix 3-A, which lists the samples alphabetically.

Detections of VOCs/VPH fractions were limited to benzene, which was detected in one of the five samples. Of the SVOCs/EPH fractions, detections consisted of bis(2-ethylhexyl)phthalate (in one of the five samples [20%]), di-n-butylphthalate (40%), and four of the PAHs: benzo(a)pyrene (40%), benzo(b)fluoranthene (20%), dibenzo(a,h)anthracene (20%), and phenanthrene (20%).

Direct Contact Screening Evaluation

Concentrations of analyzed constituents consistently met the direct contact SLs. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogens were compared to the MTGW SLs. Concentrations of those constituents consistently met the MTGW SLs.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (0 of 21 samples [100% of the samples])
- Arsenic (0 of 21 samples [0% of the samples])
- Barium (2 of 21 samples [10% of the samples])
- Beryllium (10 of 21 samples [48% of the samples])
- Cadmium (0 of 21 samples [0% of the samples])
- Chromium (0 of 21 samples [0% of the samples])

- Cobalt (0 of 21 samples [0% of the samples])
- Copper (1 of 21 samples [5% of the samples])
- Lead (2 of 21 samples [10% of the samples])
- Mercury (0 of 21 samples [0% of the samples])
- Nickel (0 of 21 samples [0% of the samples])
- Selenium (0 of 21 samples [0% of the samples])
- Silver (8 of 21 samples [38% of the samples])
- Vanadium (2 of 21 samples [10% of the samples])
- Zinc (0 of 21 samples [0% of the samples])

Subsurface Soil Results

Subsurface soil samples were not collected.

Geographic Evaluation

As depicted on Figure 3.4-1, the concentrations of constituents in the program samples consistently met the applicable SLs. The samples in which arsenic or vanadium was higher than the background value were located on the elementary school playground (ESPG-C1) and at location TB34-DW08. Note that concentrations of arsenic and vanadium in the surface soil samples collected within Tank Berm 34 were consistently below the background values.

3.5 PIPELINE CORRIDORS

Surface and subsurface piping was used during the operational life of the former refinery to convey crude oil, intermediary products, and finished products to and from storage tanks, refining units, and loading/unloading areas. Surface piping and a portion of the subsurface piping were removed in the 1960s following the sale of the property by Texaco. Remaining subsurface piping was removed by Texaco between 1999 and 2001 in accordance with the Facility's approved VCP. Descriptions of the pipeline removal activities and associated soil sampling were included in correspondence to MDEQ dated March 3, 2000 (TRMI 2000), and August 15, 2001 (TRMI 2001b).

3.5.1 INVESTIGATION METHODS

A two-phased approach was used to meet the objectives of the pipeline corridor investigation. The first phase consisted of completing direct push borings at selected locations along the former piping runs, and collecting soil samples for field screening and laboratory analysis. Data from this initial phase was evaluated, and a second phase was conducted

to fill identified data gaps. Field investigation activities included completion of soil borings, field screening, sample collection, and sample analysis; which were conducted in accordance with the FSP and QAPP.

Borings were completed using direct push technology that used a minimum 2-inch diameter core barrel. Borings were completed through the overburden sediments and terminated at a depth of 10 ft-bgs or refusal. Subsurface piping was generally found at depths of 2 to 6 ft-bgs during piping removal activities conducted between 1999 and 2001. Continuous core samples were collected using disposable acetate liners (or equivalent) in the core barrel. The soil cores were logged under the supervision of a geologist and recorded on the appropriate forms, as indicated in the FSP.

3.5.1.1 INITIAL INVESTIGATION

The boring locations for the first phase of the investigation are identified on Figure 3-2. Approximately seventy-five locations were selected based on previous sampling results (TPH greater than 200 ppm), and at the locations of former piping intersections, joints, and valves. Proposed locations were selected to provide a minimum coverage of one sample for every 150 feet of piping corridor. As indicated in the Phase II RI Work Plan, sample locations from the 1999-2001 activities that had TPH results greater than 200 ppm, but were subsequently excavated, were not considered for further investigation. However, given the approximate 150-foot spacing of soil boring locations, some boring locations approached previously excavated areas. Excavated areas are shown in green on Figure 3-2.

3.5.1.2 STEP-OUT AND/OR DELINEATION SAMPLING

Data collected during the first phase was evaluated to determine if gaps existed. Gaps did exist and additional boring locations were selected for placement. Boring locations were sited adjacent to those initial sample locations (i.e., perpendicular to the piping corridor). Once proposed boring locations were selected, data/borings from other programs were examined to determine if there was overlap. Locations that overlapped with locations from other programs, or had parent samples with sample intervals collected in the smear zone were removed. Adjacent boring locations were completed approximately 75 feet from the initial sampling location, and perpendicular to the former pipeline.

3.5.2 DEVIATIONS FROM WORK PLAN

There were deviations from the work plan during the pipeline corridor investigation. Deviations from the work plan included visual trench depth indicators, boring depths at select locations, and elimination of proposed locations from the pipeline corridor sampling program.

Per the work plan, sampling was to be conducted 1 to 2 feet below the estimated depth of the former piping. It was anticipated that there would be a noticeable difference in the hardness of soil between disturbed and undisturbed

material, which could be used as an indicator of the trench bottom. However, during the installation of soil borings there was no discernible difference in soil hardness with increased depth, and therefore this was not able to be used as an indicator of pipeline trench bottom. Additionally, it was anticipated that refusal would be encountered during the installation of borings. Refusal was not encountered and most borings terminated at 10 ft-bgs. Borings were completed at a number of locations to obtain information about and determine the presence or absence of deeper impacts, potentially associated with impacted groundwater.

Another deviation from the work plan was the elimination of five proposed locations from the sampling program. Two locations were situated within the Main Cell Landfill and eliminated. Two other locations were eliminated based on proximity to samples collected as part of other investigation programs. One location was eliminated due to proximity to a VCP excavation; while not located within the excavation it was determined that nearby subsurface points provided sufficient data.

Upon completion of the initial pipeline corridor sampling it was determined that step-out sampling for select locations would be warranted, based upon laboratory analytical results. Nine locations were identified in the November 5, 2010 letter to MDEQ, but after further review of the laboratory data one location was removed. Of the remaining eight locations, only PC-Q12-DP01 required a step-out. The remaining seven step-out locations (PC-G06-DP01, PC-G06-DP02, PC-G07-DP01, PC-I08-DP01, PC-N08-DP02, PC-P14-DP01, and PC-Q13-DP01) were not installed (see Table 3-2 for rationale).

3.5.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 111 samples consisting of 72 environmental samples, 9 blind duplicates, 10 equipment blanks, and 20 trip blanks, were collected between August 2010 and November 2011. This collection effort resulted in approximately 9,118 sample results including: 6,616 environmental sample results, 880 field duplicate sample results, 822 equipment blank sample results, and 800 trip blank sample results. The sample results were reported in 22 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the method detection limit MDL but less than the RL. The laboratory also qualified data with E flags if the results exceeded the calibration range.

Unless qualified for other reasons in the data validation review, laboratory J and E flags were preserved in the data as J data flags. A total of 290 sample results were qualified as J or E by the laboratory. Out of these laboratory flags, 1 E flag and 202 J flags were preserved during Tier III DV.

The following table summarizes the distribution of applied data qualification flags.

Flag	Total
J	632
UJ	540
JB	88
R	10
TOTAL	1,270

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal requirements specified in the QAPP were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	20	27.8%	1 per cooler*
Equipment Blanks	10	13.9%	5%
Blind Duplicates	9	12.5%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 7,496 environmental and field duplicate sample results reported and validated between August 2010 and November 2011, 7 sample results were rejected as a result of this data review. The completeness measure for the data generated for the sampling activities in the pipeline corridor investigation is 99.91%, which is greater than the required 90%.

3.5.4 RESULTS

In this section, the soil sampling program for the pipeline corridors investigation refers to samples with “PC” prefixes. The sampling was conducted during August 2010, after submittal of both the CSM Update Report and the CSM Update Addendum; therefore, no analytical results for this program were included in either of those reports. Subsurface piping was typically buried at depths of 2 to 6 ft-bgs. Therefore, the pipeline corridor investigation focused on subsurface soils. A total of 69 subsurface soil samples were collected and analyzed for the COI list constituents. In addition, two surface soil samples were collected on the basis of XRF field screening results and analyzed for lead.

Figures 3-1 and 3-2 show the locations of the pipeline corridors investigation and serve as keys to the surface data summary maps (Figures 3-3A and -3B) and the subsurface data summary maps (Figures 3-4A and -4B). The data summary maps show the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In addition, Figures 3-3A/3B and 3-4A/4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.5-1 and 3.5-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Figures 3-3A and 3-3B and Table 3.5-1 summarize the analytical results for the two PC-prefix surface soil samples. Analytical results for the surface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically. For the two surface soil samples collected, lead was detected in both samples at concentrations below the SL of 400 mg/kg. Lead was detected in one of the two samples at a concentration above the site-specific background value. The two sample locations are shown on Figure 3-3B.

Subsurface Soil Results

Figures 3-4A and 3-4B and Table 3.5-2 summarize the analytical results for the PC-prefix subsurface soil samples. Analytical results for the PC-prefix subsurface soil samples, as well as the other project subsurface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

In summary, sixteen VOCs, fourteen SVOCs, and all six hydrocarbon fractions were each detected in at least one sample. Hexane (detected in 16% of the samples) was the most frequently detected VOC. Ethylbenzene, isopropylbenzene, n-propylbenzene, and sec-butylbenzene were each detected in at least 10% of the samples. Each of the remaining detected VOCs were reported in less than 10% of the samples. The most frequently detected SVOCs were PAHs: benzo(a)pyrene (14% of the samples), 1-methylnaphthalene (10%), and phenanthrene (10%). The remaining SVOCs were detected in less than 10% of the samples. Each of the hydrocarbon fractions was detected in 9% to 10% of the samples.

Direct Contact Screening Evaluation

Constituents in the PC- subsurface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs:
 - 1,2,4-Trimethylbenzene (1 of 69 samples [1% of the samples])
- SVOCs: None
- Carbon Fractions: None
- Inorganics: Antimony (1 of 69 samples [1% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figures 3-4A and 3-4B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the PC- subsurface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (3 of 69 samples [4% of the samples])
- SVOCs:
 - 1-Methylnaphthalene (7 of 69 samples [10% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figures 3-4A and 3-4B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3).

Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (69 of 69 samples [100% of the samples])
- Arsenic (1 of 69 samples [1% of the samples])
- Barium (2 of 69 samples [3% of the samples])
- Beryllium (41 of 69 samples [59% of the samples])
- Cadmium (0 of 69 samples [0% of the samples])
- Chromium (3 of 69 samples [4% of the samples])
- Cobalt (7 of 69 samples [10% of the samples])
- Copper (1 of 69 samples [1% of the samples])
- Lead (2 of 69 samples [3% of the samples])
- Mercury (2 of 69 samples [3% of the samples])
- Nickel (0 of 69 samples [0% of the samples])
- Selenium (2 of 69 samples [3% of the samples])
- Silver (69 of 69 samples [100% of the samples])
- Vanadium (14 of 69 samples [20% of the samples])
- Zinc (1 of 69 samples [1% of the samples])

Geographic Evaluation

The former pipeline corridors cross through areas assessed as part of the tank berm, tank farm, VCP, and railroad loading rack investigations, which are discussed in Sections 3.1, 3.2, 3.6, and 3.7, respectively. Although the laboratory results indicate that concentrations of certain constituents exceeded the SLs in certain samples, those samples are generally bounded geographically by other samples collected/analyzed during completion of the other programs.

3.6 VCP EXCAVATION AREAS

Twenty-three areas excavated during the VCP required verification sampling, per guidelines in the November 5, 2010 letter from CEMC to MDEQ. This included an excavation in former Tank Berm 13, which was not investigated during activities to update the CSM due to proximity to roadways and the soil storage area. The excavated areas vary in size and proximity to one another, and are depicted on Figure 3.6-1. The majority of these areas are located on what is now private property.

3.6.1 INVESTIGATION METHODS

Excavations performed during the VCP varied in depth. Records indicate the shallowest excavations were approximately two feet deep. All excavations were backfilled with clean soil. Verification sampling in excavated areas followed the subsurface soil sampling protocol, except screening/sampling began at depths of 2 ft-bgs. Soil borings were advanced to a depth of approximately 10 ft-bgs (or greater, if information indicated that an excavation was deeper), and samples submitted for analysis of the Facility COI list in order to evaluate the soils present beneath the floor of the historical excavation.

VCP excavation areas were identified and grid systems established over each former excavation. Two sizes of grid cells were used: 50' x 50' and 75' x 75'. Determination of grid cell size was based on the footprint size of the VCP. The smaller grid size (50' x 50') was overlain on the majority of the VCP excavations areas which were smaller in size (less than 25,000 ft²). The 75' x 75' grid cell size was used on three VCP excavations: VCP01, VCP02, and VCP23, due to the footprint of each being greater than 25,000 ft². Additionally, while it was determined to overlay the 75 foot grid on these larger excavations, it was recognized that additional sampling could be warranted based on the results from the selected locations. After the initial investigation, it was determined that no additional sampling was required at this time.

One exception to applying a grid cell size was VCP22, which was approximately 63,000 ft² but almost entirely eliminated with the installation of the Main Cell Landfill. VCP22 was overlain with a 50' x 50' grid because the accessible footprint (not covered by the Main Cell Landfill) was smaller than 25,000 ft².

3.6.2 DEVIATIONS FROM WORK PLAN

Investigation of excavations conducted during the VCP was expanded from the estimated 15 areas to the 23 areas where verification sampling was conducted under the Phase II RI. One excavation area, the footprint of the former process area, was identified as an area that needed verification sampling. It was determined that this outline was not actually an excavation area but rather just the outline of the former process area. Further research identified a number of smaller excavation areas within this outlined area. As with the other VCP excavation areas, they were assigned an

identification name, overlain with a 50'x50' grid and investigated following the screening/sampling protocol utilized with the other VCP excavations.

One VCP excavation, VCP19, is located within Tank Berm 13. Because investigation activities for its area were conducted under the tank berm sampling program, VCP19 does not have any direct sample results associated with it. Field screening and laboratory results for VCP19 are associated with the TB13 prefix.

3.6.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 150 samples consisting of 107 environmental samples, 13 blind duplicates, 10 equipment blanks, and 20 trip blanks, were collected between December 2010 and November 2011. This collection effort resulted in approximately 14,046 sample results including: 11,021 environmental sample results, 1,255 field duplicate sample results, 930 equipment blank sample results, and 840 trip blank sample results. The data were reported in 24 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. The laboratory also qualified data with J flags if the results were below the calibration range. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 515 sample results were qualified as J by the laboratory. Out of these laboratory J flags, 298 were preserved during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	1,309
UJ	1,201
JB	149
R	183
TOTAL	2,842

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal requirements specified in the QAPP were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	20	18.7%	1 per cooler*
Equipment Blanks	10	9.3%	5%
Blind Duplicates	13	12.1%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 12,276 environmental and field duplicate sample results reported and validated between December 2010 and November 2011, 183 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the sampling activities in the VCP excavation areas is 98.51%, which is greater than the required 90%.

3.6.4 RESULTS

In this section, the soil sampling program pertaining to the VCP excavation areas refers to samples with “VCP” prefixes. Sampling events for this program were conducted during December 2010, April 2011, and November 2011 and resulted in the collection of 6 surface and 98 subsurface soil samples. Those samples were analyzed for the COI list constituents. Note that the sampling events discussed herein were conducted after submittal of both the CSM Update and the CSM Update Addendum; therefore, analytical results for this program were not included in either of those reports.

Figures 3-1 and 3-2 show the VCP areas and serve as keys to the surface data summary maps (Figures 3-3A and -3B) and the subsurface data summary maps (Figures 3-4A and 3-4B). The first map in each set (i.e., Figures 3-3A and -4A) depicts the western half of the overall project area, while the second map (i.e., Figures 3-3B and 3-4B) depicts the eastern half. The VCP areas are located in the eastern portion of the overall Phase II RI project area and therefore are located on Figures 3-3B and 3-4B. The data summary maps show the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In

addition, Figures 3-3A/3-3B and 3-4A/3-4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.6-1 and 3.6-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Figure 3-3B and Table 3.6-1 summarize the analytical results for the surface soil samples. Analytical results for the VCP-prefix surface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

In summary, VOC detections were limited to one of the six samples (VCP14-B07-DP01 [1.5-3.5 ft]), which contained sec-butylbenzene, ethylbenzene, isopropylbenzene, and n-propylbenzene. SVOCs were detected more frequently, with detections limited to the following eight PAHs: benzo(a)pyrene (17% of the samples), benzo(b)fluoranthene (33%), chrysene (33%), fluoranthene (33%), indeno(1,2,3-cd)pyrene (33%), naphthalene (17%), phenanthrene (50%), and pyrene (33% of the samples). Each of the hydrocarbon fractions was detected in at least one of the samples.

Direct Contact Screening Evaluation

Constituents in the VCP- subsurface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs: None
- SVOCs: None
- Carbon Fractions:
 - C5-C8 aliphatic (1 of 6 samples [17% of the samples])
 - C9-C10 aromatic (1 of 6 samples [17% of the samples])
 - C9-C12 aliphatic (1 of 6 samples [17% of the samples])
 - C9-C18 aliphatic (1 of 2 samples [50% of the samples])

- Inorganics:
 - Lead (4 of the 6 samples [67% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figures 3-4A and 3-4B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogens were compared to the MTGW SLs. Concentrations of those constituents consistently met the MTGW SLs.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (6 of 6 samples [100% of the samples])
- Arsenic (0 of 6 samples [0% of the samples])
- Barium (0 of 6 samples [0% of the samples])
- Beryllium (2 of 6 samples [33% of the samples])
- Cadmium (2 of 6 samples [33% of the samples])
- Chromium (1 of 6 samples [17% of the samples])
- Cobalt (0 of 6 samples [0% of the samples])
- Copper (2 of 6 samples [33% of the samples])
- Lead (4 of 6 samples [67% of the samples])
- Mercury (0 of 6 samples [0% of the samples])
- Nickel (0 of 6 samples [0% of the samples])
- Selenium (0 of 6 samples [0% of the samples])
- Silver (0 of 6 samples [0% of the samples])

- Vanadium (2 of 6 samples [33% of the samples])
- Zinc (1 of 6 samples [17% of the samples])

Subsurface Soil Results

Figure 3-4B and Table 3.6-2 summarize the analytical results for the 98 subsurface soil samples. Analytical results for the VCP-prefix subsurface soil samples, as well as the other project subsurface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

In summary, eighteen VOCs, twenty-one SVOCs, and all six hydrocarbon fractions were each detected in at least one sample. Benzene, sec-butylbenzene, ethylbenzene, isopropylbenzene, n-propylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene were detected in 24% to 27% of the samples. The most frequently detected SVOCs were PAHs: benzo(a)pyrene (18% of the samples), fluorene (18%), 1-methylnaphthalene (28%), 2-methylnaphthalene (19%), and phenanthrene (20%). Each of the hydrocarbon fractions was detected in 27% to 39% of the samples.

Direct Contact Screening Evaluation

Constituents in the VCP- subsurface samples exceeding the direct contact SLs consisted of the following:

- VOCs:
 - 1,2,4-Trimethylbenzene (7 of 98 samples [7% of the samples])
- SVOCs:
 - 1-Methylnaphthalene (1 of 98 samples [1% of the samples])
 - 2-Methylnaphthalene (1 of 98 samples [1% of the samples])
- Carbon Fractions:
 - C5-C8 aliphatic (4 of 98 samples [4% of the samples])
 - C9-C10 aromatic (3 of 98 samples [3% of the samples])
 - C9-C12 aliphatic (2 of 98 samples [2% of the samples])
 - C9-C18 aliphatic (3 of 67 samples [4% of the samples])
- Inorganics:
 - Lead (3 of 98 samples [3% of the samples])

The locations at which one or more constituents exceeded the direct contact SLs are indicated on Figure 3-4B with color-coded symbols. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the VCP- subsurface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (11 of 98 samples [11% of the samples])
 - Ethylbenzene (2 of 98 samples [2% of the samples])
- SVOCs:
 - 1-Methylnaphthalene (24 of 98 samples [24% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figure 3-4B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (98 of 98 samples [100% of the samples])
- Arsenic (0 of 98 samples [0% of the samples])
- Barium (2 of 98 samples [2% of the samples])
- Beryllium (29 of 98 samples [30% of the samples])
- Cadmium (11 of 98 samples [11% of the samples])
- Chromium (22 of 98 samples [22% of the samples])
- Cobalt (10 of 98 samples [10% of the samples])
- Copper (7 of 98 samples [7% of the samples])
- Lead (18 of 98 samples [18% of the samples])

- Mercury (10 of 98 samples [10% of the samples])
- Nickel (14 of 98 samples [14% of the samples])
- Selenium (6 of 98 samples [6% of the samples])
- Silver (74 of 98 samples [76% of the samples])
- Vanadium (25 of 98 samples [26% of the samples])
- Zinc (2 of 98 samples [2% of the samples])

Geographic Evaluation

The VCP excavation area samples were collected near the eastern edge of the project area. Impacts are further delineated by other program samples collected as part of the investigations of the former pipeline corridors, railroad loading racks, and wastewater disposal area, which are discussed in Sections 3.5, 3.7 and 3.8, respectively. Taken together, the results of these programs delineate the extent of impacts associated with the VCP excavation areas.

3.7 RAILROAD LOADING/OFF-LOADING RACK AREAS

The railcar loading/off-loading rack (“loading rack”) associated with the former Sunburst Texaco refinery was oriented north-south, parallel to the railroad. The loading rack was approximately 1,629 feet long and was located east of the former process area. The loading rack was used to unload raw materials and additives from railcars, as well as loading products for shipment. The infrastructure associated with the loading rack generally consisted of pumping equipment, conveyance piping, and a rail siding. Results from the investigation are discussed in Section 3.7.4.

A second railcar loading/off-loading rack was located to the south, outside of the former Sunburst Texaco refinery property. That loading rack was associated with the Snow Cap refinery, which was located immediately to the south. Based on review of an aerial photograph from 1961, that loading rack was approximately 800 feet long and located at the east boundary of the Snow Cap refinery, adjacent to the railroad. In reviewing aerial photographs, it appears the northern most portion of the Snow Cap railroad loading racks extended partially onto the former Sunburst Texaco refinery property. Remediation and investigation activities already have been conducted in that area as part of the 1999-2001 VCP and the 2009-2010 CSM Update data collection activities. Additional investigation activities therefore were conducted in the former Snow Cap loading rack area to assess whether releases from Texaco leased tanks or pipelines have impacted this area, and to complete the delineation of the boundaries of the Facility.

3.7.1 INVESTIGATION METHODS

Field investigation activities, including completion of soil borings, field screening, sample collection and analysis were conducted as described in Section 2.1.1 and in accordance with the Facility FSP and Phase II RI Work Plan.

Based on inspections during development of the work plan, there does not appear to be any ballast present in the former railroad loading rack area. The area contains a red gravel material, which does not resemble railroad ballast; the gravel is comprised of much finer material and significantly differs in color than ballast currently in place along the BNSF tracks. Absence of ballast is likely due to the excavation activities that were conducted in August 2000 as part of the VCP. As such, surface material currently present in this area is likely not representative of that which was present during refinery operations. Ballast sampling was not conducted because it appears that all ballast has been removed.

3.7.2 DEVIATIONS FROM WORK PLAN

The presence of underground utilities located between the county road and railroad track necessitated the adjustment of boring locations. In addition, per the access agreement with BNSF, personnel and investigation activities were required to stay a minimum of 20 feet from the active rail line. This requirement required adjustment to a number of locations that were within the 20 foot railroad buffer. Adjustment of these points did not compromise the purpose of the selected locations.

3.7.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 133 samples consisting of 108 environmental samples, 10 blind duplicates, 4 equipment blanks, and 11 trip blanks, were collected between October 2011 and November 2011. This collection effort resulted in an estimated total of 9,141 sample results including; 7,704 environmental sample results, 625 field duplicate sample results, 372 equipment blank sample results, and 440 trip blank sample results. The results were reported in 16 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 538 data points were qualified as J by the laboratory. Out of these laboratory J flags, 372 were preserved during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	1,134
UJ	1,107
JB	84
R	225
TOTAL	2,550

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal requirements were not met for equipment blanks and blind duplicates. However, these samples are part of a larger project in which overall equipment blank and blind duplicate adequacy was met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	11	10.2%	1 per cooler*
Equipment Blanks	4	3.7%	5%
Blind Duplicates	10	9.3%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 8,329 environmental and field sample results reported and validated between October 2011 and November 2011, 225 were rejected as a result of this data review. The completeness measure for the data generated for the sampling activities in railroad loading rack areas is 97.30%, which is greater than the required 90%.

3.7.4 RAILROAD LOADING RACK INVESTIGATION RESULTS

In this section, the railroad loading rack investigation refers to samples with “RR” prefixes. Samples were collected between August 2010 and November 2011 according to the Phase II RI Work Plan. The presentation of results is inclusive of those samples collected from both railcar loading racks (the one associated with the former Sunburst Texaco refinery and the one associated with the former Snow Cap refinery).

Figures 3-1 and 3-2 show the locations of the railroad loading rack areas, as well as the surface sample and subsurface sample locations, respectively. Figures 3-1 and 3-2 serve as keys to the surface data summary maps (Figures 3-3A and 3-3B) and the subsurface data summary maps (Figures 3-4A and -4B). The data summary maps show the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In addition, Figures 3-3A/3B and 3-4A/4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation Approach

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.7-1 and 3.7-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

The railroad loading rack investigation included collection of 36 surface samples for laboratory analysis. Figure 3-3B and Table 3.7-1 summarize the analytical results for the surface soil samples. Analytical results for the “RR” prefix surface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

Thirteen VOCs, eighteen SVOCs, and all six hydrocarbon fractions were detected in at least one sample. Isopropyl benzene (3 samples; 10%), hexane (3 samples; 10%), and toluene (3 samples; 10%) were the most frequently detected VOCs. Several PAHs, including anthracene, benzo(a)pyrene, benzo(b)fluoranthene, chrysene, fluoranthene, indeno(1,2,3-cd) pyrene, 1-methyl naphthalene, phenanthrene, and pyrene were detected in at least half (53%-89%) of the samples. The heavier hydrocarbon fractions (C11-C22 aromatic [93%]; C19-C36 aliphatic [93%]; and C9-C18 aliphatic [67%]) were each also detected in greater than 50% of the samples.

Direct Contact Screening Evaluation

Constituents in the RR- surface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs: None
- SVOCs:

- Benzo(a)anthracene (2 of 36 samples [6% of the samples])
- Benzo(a)pyrene (21 of 36 samples [58% of the samples])
- Benzo(b)fluoranthene (11 of 36 samples [31% of the samples])
- Dibenzo(a,h)anthracene (8 of 36 samples [22% of the samples])
- Indeno(1,2,3-cd)pyrene (10 of 36 samples [28% of the samples])
- Carbon Fractions:
 - C9-C18 aliphatic (6 of 30 samples [20% of the samples])
 - C11-C22 aromatic (9 of 30 samples [30% of the samples])
- Inorganics:
 - Antimony (2 of 36 samples [6% of the samples])
 - Lead (7 of 36 samples [19% of the samples])
 - Mercury (2 of 36 samples [6% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figure 3-3B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the RR- surface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (2 of 30 samples [7% of the samples])
- SVOCs:
 - 1-Methylnaphthalene (10 of 36 samples [28% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figure 3-3B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3).

Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (36 of 36 samples [100% of the samples])
- Arsenic (3 of 36 samples [8% of the samples])
- Barium (1 of 36 samples [3% of the samples])
- Beryllium (8 of 36 samples [22% of the samples])
- Cadmium (10 of 36 samples [28% of the samples])
- Chromium (1 of 36 samples [3% of the samples])
- Cobalt (6 of 36 samples [17% of the samples])
- Copper (22 of 36 samples [61% of the samples])
- Lead (32 of 36 samples [89% of the samples])
- Mercury (23 of 36 samples [64% of the samples])
- Nickel (2 of 36 samples [6% of the samples])
- Selenium (3 of 36 samples [8% of the samples])
- Silver (10 of 36 samples [28% of the samples])
- Vanadium (2 of 36 samples [6% of the samples])
- Zinc (17 of 36 samples [47% of the samples])

Delineation Evaluation

According to the protocol specified in the Phase II RI Work Plan, where impacts were identified, additional samples were collected for delineation. In addition, during the completion of the investigation of the portion of the railcar loading area located west of the former wastewater disposal area, elevated lead concentration in surface soils were observed. After consultation with MDEQ, a combination of field screening of surface soils with XRF and direct push borings was used to delineate the extent of lead impacts to soil eastward, away from the railroad tracks and into the wastewater disposal area. As shown on Figure 3-3B, surface soil impacts at the former railroad loading rack are generally delineated as follows:

- By the railroad tracks to the east, and former wastewater disposal area program samples (“FE” prefixes) on the east side of the railroad tracks
- By sample location RR-Q04-DP01 to the north
- By ASC area 10, which is visually identifiable at the ground surface, on the southeast

Delineation to the west is constrained by the presence of the road, and inaccessible areas such as the Construction/ Demolition Debris landfill and the Lagoons Landfill. If necessary during the scoping of any remedial activities in this area, additional delineation to the west may be considered between these two former units. Additional delineation may also be considered to the south and southwest, in the vicinity of areas investigated for impacts from non-petroleum related sources (DEQ-prefix samples) and sample location RR-Q16-DP01 (associated with the railcar loading rack). Benzo(a)anthracene and benzo(a)pyrene were detected at concentrations above direct contact screening criteria at this location. These compounds and other PAHs are found in petroleum products and are frequently associated with refinery sites (USEPA 2008a), and are commonly detected above direct contact screening criteria in surface soils in areas of industrial/commercial development (ATSDR 1999, Wang et al. 2008).

Subsurface Soil Results

The former railroad loading rack investigation also included collection of 42 subsurface soil samples for laboratory analysis of the COI list constituents. The subsurface samples were collected in 2010 and 2011 pursuant to the Phase II RI Work Plan. Figure 3-4B and Table 3.7-2 summarize the analytical results for the subsurface soil samples. Analytical results for the RR- subsurface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

Fifteen petroleum hydrocarbon VOCs were detected in one or more subsurface soil samples. The constituent sec-butylbenzene was the VOC detected with the highest frequency (in 6 samples; 14%). Phenanthrene (14 samples; 39%), chrysene (14 samples; 39%), fluorene (9 samples; 25%), 1-methylnaphthalene (9 samples; 25%), and pyrene (9 samples; 25%) were the most frequently detected PAHs. All six hydrocarbon fractions were detected at frequencies ranging between 14% and 95%.

Direct Contact Screening Evaluation

Constituents in the RR- subsurface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs:
 - 1,2,4-Trimethylbenzene (2 of 42 samples [5% of the samples])
- SVOCs: None



- Carbon Fractions:
 - C5-C8 aliphatic (2 of 42 samples [5% of the samples])
 - C9-C12 aliphatic (1 of 42 samples [2% of the samples])
- Inorganics: None

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figure 3-4B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the RR- subsurface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs:
 - Benzene (2 of 42 samples [5% of the samples])
- SVOCs:
 - 1-Methylnaphthalene (6 of 36 samples [17% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figure 3-4B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (36 of 36 samples [100% of the samples])
- Arsenic (1 of 36 samples [3% of the samples])
- Barium (6 of 36 samples [17% of the samples])
- Beryllium (9 of 36 samples [25% of the samples])
- Cadmium (0 of 36 samples [0% of the samples])
- Chromium (2 of 36 samples [6% of the samples])
- Cobalt (0 of 36 samples [0% of the samples])

- Copper (3 of 36 samples [8% of the samples])
- Lead (3 of 36 samples [8% of the samples])
- Mercury (2 of 36 samples [6% of the samples])
- Nickel (1 of 36 samples [3% of the samples])
- Selenium (3 of 36 samples [8% of the samples])
- Silver (9 of 36 samples [25% of the samples])
- Vanadium (6 of 36 samples [17% of the samples])
- Zinc (0 of 36 samples [0% of the samples])

Delineation Evaluation

According to the protocol specified in the Phase II RI Work Plan, where impacts were identified, additional samples were collected for delineation. As shown on Figure 3-4B, subsurface soil impacts at the former railroad loading rack are generally delineated. Delineation in some places may be limited by access due to the presence of the road and landfills to the west and the railroad tracks to the east. Additional delineation of subsurface impacts may be considered as the scope of any remedial activities in this area is finalized.

3.8 FORMER WASTEWATER DISPOSAL AREA

The refinery's former wastewater disposal area, which is bermed and covers approximately 31 acres, is located east of the railroad tracks. During refinery operation, wastewater was routed through an oil trap located near the southeast corner of the process area. The trap skimmed petroleum products from the water for recycling or incineration, and the resulting wastewater was channeled to the wastewater treatment area. Examination of available aerial photographs for the refinery reveals that during the early period of refinery operation, the wastewater treatment area contained a single surface impoundment, with discharge directly to the unnamed lake. At some time after 1941 (but before 1951) the area was bermed, and two smaller surface impoundments/settling ponds were added. All of the small surface impoundments/settling ponds were located in the southwest corner of the bermed area. Two of the surface impoundments were connected by a waterdraw whereby any lighter floating petroleum products were skimmed from one lagoon and incinerated in a small brick kiln located adjacent to the lagoons. The wastewater then flowed into the other lagoon through the waterdraw, and eventually into the large bermed area, for evaporation. The bermed area was connected by an overflow culvert to the unnamed lake, and aerial photos show discharge of waters from the bermed wastewater disposal area to the unnamed lake.



3.8.1 INVESTIGATION METHODS

The initial investigation of the former wastewater treatment area was conducted in conjunction with the investigation of the railroad loading racks. There was no formal work plan submitted for the initial round of sampling. Instead, as assessment occurred and evidence of impacts was noted in surface and subsurface soils in the railcar loading rack, the decision was made to assess locations beyond those areas and extending into the former wastewater disposal area. Investigation and sampling methods were performed in accordance with previously approved procedures outlined in the FSP.

3.8.1.1 INITIAL INVESTIGATION

Initial investigation of the wastewater disposal area and surrounding areas was modeled after the Tank Farm/Tank Berm programs with input from MDEQ (email from Chris Cote to Pat Henricks, October 31, 2011). Impacts in the subsurface were observed within the BNSF right-of-way (in the railcar loading rack area, west of the railroad tracks) during the railcar loading rack investigation. Therefore, several exploratory soil borings were installed immediately to the east of the impacted area (and east of the BNSF right-of-way) for purpose of determining presence/absence of impacts to subsurface soils in that area, and assisting the siting of groundwater monitoring wells. In addition, lead impacts to surface soils were observed west of the railroad tracks, and exploratory screening of surface soils east of the tracks indicated that lead impacts were present there. After these initial borings/surface soil screenings, a more standardized approach was taken for purpose of data collection.

The wastewater disposal area was first overlain with a 300 foot grid and in-situ XRF screening was performed within each of the identified cells. Soil samples from a percentage of these locations were submitted to the laboratory for confirmation analysis. Additional screening was performed within cells or areas inside of the bermed wastewater disposal area where XRF readings exceeded 400 ppm, and along the perimeter berm where vegetation could potentially collect soils deposited by the wind. Seven direct push borings were also installed during this step in the investigation. Four locations were installed to a depth of 4 ft-bgs and three were installed to a depth of approximately 20 ft-bgs to delineate vertical extent and determine soil lithology across the area.

3.8.1.2 STEP-OUT AND/OR DELINEATION SAMPLING

Based on initial screening and sampling of locations, lead impacts were isolated to the upper 12 inches of soil. Step-out activities were conducted in the spring of 2012 and focused on the delineation of impacted soil east of the railroad. Step-out locations were selected for additional screening on properties surrounding the wastewater disposal area, and are based upon elevated reading from the initial investigation. Each location was bored to 2 ft-bgs and each 0.5 foot interval was screened with the XRF. Laboratory samples were collected and submitted based upon the screening

results. At the time of sample collection the moisture content in the soil was elevated. To obtain quality screening results, soil samples were air dried prior to screening.

Four samples were collected in grid column 'R' (FES1-R04-SS01, FES1-R04-SS02, FES1-R05-SS01, and FES1-R05-SS02) for SVOC analysis only, to define extent of observed impacts associated with the railcar loading area on the west side of the railroad tracks. All other samples collected as part of the step-out/delineation sampling were analyzed for lead only. Sampling on the Bureau of Land Management (BLM) property was limited to the edge of grid column 'V' (approximately 300' east of the eastern edge of the bermed wastewater disposal area) per the access agreement between the BLM and CEMC.

3.8.2 DEVIATIONS FROM WORK PLAN

There was no formal work plan developed for the investigation performed in the former Wastewater Disposal Area. As such, there are no deviations from the work plan. Additional delineation/step-out sampling was addressed in a letter to MDEQ, dated March 2, 2012. The letter indicated that every effort would be made to collect samples prior to the wet season. Generally, this occurred; however, the soil samples that were collected as part of the step-out sampling in April 2012 had significant moisture content. Samples were dried to obtain a quality reading with the XRF (high moisture content in soils can significantly affect its accuracy), prior to screening the soil.

3.8.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 80 samples consisting of 64 environmental samples, 7 blind duplicates, 4 equipment blanks, and 5 trip blanks were collected between December 2010 and April 2012. This collection effort resulted in approximately 1,984 sample results including: 1,399 environmental sample results, 105 field duplicate sample results, 280 equipment blank sample results, and 200 trip blank sample results. The sample results were presented in 11 lab data packages that were reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 69 sample results were qualified as J by the laboratory. Out of these laboratory J flags, 50 were preserved during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	129
UJ	82
JB	25
R	0
TOTAL	236

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal met the requirements specified in the QAPP. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	5	7.8%	1 per cooler*
Equipment Blanks	4	6.3%	5%
Blind Duplicates	7	10.9%	10%

Of the 1,504 environmental and field duplicate sample results reported and validated between December 2010 and April 2012, none were rejected as a result of the data validation review. The completeness measure for the data generated for the sampling activities in the Wastewater Lagoon is 100.0%, which is greater than the required 90%.

3.8.4 RESULTS

In this section, the investigation pertaining to the former wastewater disposal area refers to samples with “FE” prefixes. Sampling events were conducted during December 2010, November 2011, January 2012, and April 2012. Note that the sampling events discussed herein were conducted after submittal of both the CSM Update and the CSM Update Addendum. Therefore, analytical results for this program were not included in either of those reports.

The surface soil program consisted of collection of five samples for the full Facility COI list analysis, with four additional samples analyzed for just SVOCs. In addition, 43 surface soil samples were submitted to the laboratory

specifically for lead analysis. The subsurface soil investigation included collection of seven samples, which were analyzed for the full Facility COI list. Based on initial screening and sampling of locations, lead impacts are isolated to the upper 12 inches of soil.

Figures 3-1 and 3-2 show the former wastewater disposal area and serve as keys to the surface data summary maps (Figures 3-3A and -3B) and the subsurface data summary maps (Figures 3-4A and -4B). The first map in each set (i.e., Figures 3-3A and 3-4A) depicts the western half of the overall project area, while the second map (i.e., Figures 3-3B and 3-4B) depicts the eastern half. The former wastewater disposal area is located in the eastern portion of the overall Phase II RI project area and is therefore shown on Figures 3-3B and 3-4B. The data summary maps depict the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). In addition, Figures 3-3B and 3-4B summarize the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.8-1 and 3.8-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Figure 3-3B and Table 3.8-1 summarize the analytical results for the surface soil samples. Analytical results for the former wastewater disposal area surface soil samples, as well as the other project surface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

Concentrations of VOCs and the three lighter carbon fractions were below the detection limits. All three heavier carbon fractions and fifteen SVOCs were detected in surface soil samples. Phenanthrene was detected most frequently (78% of the samples), while chrysene (56%) and 1-methylnaphthalene (56%) were also detected in more than half of the program samples.

Direct Contact Screening Evaluation

Constituents in the FE- surface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs: None
- SVOCs: None
- Carbon Fractions: None
- Inorganics:
 - Lead (4 of 48 samples [8% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figure 3-3B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogens were compared to the MTGW SLs. Concentrations of those constituents consistently met the MTGW SLs.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (5 of 5 samples [100% of the samples])
- Arsenic (0 of 5 samples [0% of the samples])
- Barium (0 of 5 samples [0% of the samples])
- Beryllium (4 of 5 samples [80% of the samples])
- Cadmium (0 of 5 samples [0% of the samples])
- Chromium (4 of 5 samples [80% of the samples])
- Cobalt (2 of 5 samples [40% of the samples])
- Copper (3 of 5 samples [60% of the samples])
- Lead (45 of 48 samples [94% of the samples])

- Mercury (3 of 5 samples [60% of the samples])
- Nickel (3 of 5 samples [60% of the samples])
- Selenium (4 of 5 samples [80% of the samples])
- Silver (1 of 5 samples [20% of the samples])
- Vanadium (4 of 5 samples [80% of the samples])
- Zinc (3 of 5 samples [60% of the samples])

Subsurface Soil Results

Figure 3-4B and Table 3.8-2 summarize the analytical results for the seven subsurface soil samples. Analytical results for subsurface soil samples, as well as the other project subsurface soil samples, are provided in Appendix 3-A, which lists the samples alphabetically.

In summary, the results of the VOC, SVOC, and carbon fraction analyses indicate detection of only one organic constituent, indene, which was above the detection limit in one of the seven samples.

Direct Contact Screening Evaluation

Screening levels have not been published for indene, which is the only detected organic constituent. Concentrations of inorganic constituents subject to the direct contact SLs were below those SLs. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The carcinogens concentrations were below detection limits and therefore met the MTGW SLs.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (7 of 7 samples [100% of the samples])
- Arsenic (0 of 7 samples [0% of the samples])
- Barium (0 of 7 samples [0% of the samples])

- Beryllium (6 of 7 samples [86% of the samples])
- Cadmium (0 of 7 samples [0% of the samples])
- Chromium (5 of 7 samples [71% of the samples])
- Cobalt (0 of 7 samples [0% of the samples])
- Copper (0 of 7 samples [0% of the samples])
- Lead (0 of 7 samples [0% of the samples])
- Mercury (0 of 7 samples [0% of the samples])
- Nickel (4 of 7 samples [57% of the samples])
- Selenium (2 of 7 samples [29% of the samples])
- Silver (3 of 7 samples [43% of the samples])
- Vanadium (5 of 7 samples [71% of the samples])
- Zinc (0 of 7 samples [0% of the samples])

Geographic Evaluation

The former wastewater disposal area sampling program included collection of delineation samples to verify that the extent of impacts above applicable screening levels was determined. Samples collected on the eastern edge of the evaluated area met the SLs and conservatively define the extent of impacts. If necessary as part of future investigations or evaluation of remedial options, additional samples may be collected to more precisely define the extent of impacts.

3.9 INVESTIGATION OF IMPACTS FROM NON-REFINERY SOURCES

Impacts from non-refinery sources were identified and sampled on private property, located in the former refinery footprint. MDEQ personnel identified five locations in which CEMC was required to conduct surface soil sampling (MDEQ 2010). CEMC personnel identified an additional two locations in the vicinity that were similar in nature to the five identified by MDEQ. The seven potential contaminant sources in these areas are not related to former refinery activities. One area, DEQ-SS01, appears to be a general dump area located within a small ravine. Two areas, DEQ-SS02 and DEQ-SS05, appear to be storage and/or disposal areas for treated wood poles. Three areas, DEQ-SS03, DEQ-SS04, and DEQ-SS06 contain soils apparently stained with materials from 55-gallon drums maintained in the areas. Area DEQ-SS03 houses a drum containing an unknown liquid. DEQ-SS07 was a 55-gallon drum without apparent staining; soil was sampled from the immediate vicinity. Locations of the areas are depicted on Figure 3-3B.

3.9.1 INVESTIGATION AND SAMPLING METHODS

DEQ-SS01, DEQ-SS03, DEQ-SS04, DEQ-SS06, and DEQ-SS07, were sampled using the overall sampling approach used to collect surface soil samples as outlined in the surface soil protocol presented in the Phase II RI Work Plan. Borings at each area were field screened for metals, using a portable XRF, at four intervals (0-0.5 ft-bgs, 0.5-1 ft-bgs, 1-1.5 ft-bgs and 1.5-2 ft-bgs). Discrete soil samples were collected from each boring and submitted for analyses from the 0-0.5 ft-bgs interval and the 1.5-2 ft-bgs interval. Composite samples were collected from DEQ-SS02 and DEQ-SS05. Each location had five sampling locations selected. From these five flagged locations, an equal aliquot of soil from the 0-0.5 ft-bgs interval was collected, mixed and jarred. Due to the unknown nature of material from non-refinery sources, a broader range of constituents than the Facility COI list were considered for analyses of samples. Discrete sample locations were analyzed for: VOCs (8260), SVOCs (8270), TEL (8270), metals (6010), lead (6010), cyanide (9012A), MT-EPH, MT-VPH, pesticides/herbicides (8081), dioxins/furans (8290), PCP (8540), PCBs (8082). Composite sample locations were analyzed for all of the above except VOCs and MT-VPH.

3.9.2 DEVIATIONS FROM WORK PLAN

All samples submitted to the laboratory were analyzed for the same expanded constituent list. The only exceptions were the composite samples collected from DEQ-SS02 and DEQ-SS05, which were not analyzed for VOCs or MT-VPH. Using the expanded list for all locations, instead of select areas, is a deviation from the November 5, 2010 letter from Chevron to MDEQ. Also, sample locations were placed within an area spatially, biasing locations towards spots showing visual impacts. Location selection within an area is a deviation from the November 2010 letter which indicated that: *One sample will be collected from the approximate center of the area and two to four samples will be collected from the perimeters of the areas.* In addition, CEMC collected samples from two additional areas beyond the five areas that MDEQ identified. These additional samples were collected using same sampling program and techniques as were utilized in the other five areas.

3.9.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 33 samples consisting of 27 environmental samples, 2 blind duplicates, 1 equipment blank, and 3 trip blanks were collected between September 2010 and July 2011. This collection effort resulted in approximately 5,710 sample results including: 5,121 environmental sample results, 376 field duplicate sample results, 93 equipment blank sample results, and 120 trip blank sample results. The results were reported in 3 lab data packages that were reviewed and

validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. The laboratory also qualified data with E flags if the results exceeded the calibration range and with Q flags if the result was an estimated maximum possible concentration. Unless qualified for other reasons in the data validation review, laboratory flags were preserved in the data. A total of 461 sample results were qualified as J, E, or Q by the laboratory. Out of these laboratory flags, 143 were preserved as J flags during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	666
UJ	1,049
JB	222
R	159
TOTAL	1,854

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal did not meet requirements for blind duplicates and equipment blanks that were not collected at the required frequency. However, these samples are part of a larger project in which field duplicate adequacy is met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	3	11.1%	1 per cooler*
Equipment Blanks	1	3.7%	5%
Blind Duplicates	2	7.4%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 5,497 environmental and field duplicate sample results reported and validated between September 2010 and July 2011, 159 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the sampling activities for Non-Refinery Sources is 97.11%, which is greater than the required 90%.

3.9.4 RESULTS

In this section, the investigation of impacts from non-refinery sources refers to samples with “DEQ” and “OIL-VAT” prefixes. Those samples were collected during September 2010 and July 2011. Therefore, the results were not included in either the CSM Update or the CSM Update Addendum.

The sampling program included collection and laboratory analysis of 15 surface soil samples for the COI list. However, 1,2-dichlorobenzene, 1,3-dichlorobenzene, 1,4-dichlorobenzene, and 1,4-dioxane results were only reported for three of the 15 samples. This program also included an extended analyte list in order to further characterize the impacts from potential non-refinery related sources, as described below.

Figure 3-1 serves as a key to Phase II RI project sampling areas and the surface data summary maps (Figures 3-3A and 3-3B). Figures 3-3A and -3B show the western and eastern portions of the Phase II RI project area, respectively. The samples discussed in this section were collected in the eastern portion of the project area and therefore appear on Figure 3-3B. Color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact and/or MTGW, as applicable). That evaluation was confined to the COI list constituents. In addition, Figure 3-3B summarizes the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 mg/kg.

Data Evaluation

Table 2.1-1 presents the Facility COI list along with the possible SLs for each COI. Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the surface and subsurface summary data tables (Tables 3.9-1 and 3.9-2, respectively) and comprehensive data tables (Appendix 3-A). However, the data summary maps focus on the direct contact screening level and MTGW screening level (where applicable) exceedances.

Surface Soil Results

Figure 3-3B and Table 3.9-1 summarize the analytical results for the surface soil samples. Both presentations are specific to the COI list analytes. Analytical results for the DEQ-prefix and OIL-VAT-prefix surface soil samples are

provided on a separate set of tables within Appendix 3-A; those tables list the COI list constituents plus the detected constituents from the extended analyses.

In summary, detections of the COI organic constituents were limited to SVOCs and the three heavier (EPH) hydrocarbon fractions. Twenty-two SVOCs were detected in at least one sample. The most frequently detected SVOCs were PAHs: benzo(b)fluoranthene, chrysene, fluoranthene, and pyrene, each of which was detected in 87% of the samples. The EPH hydrocarbon fractions were detected with the following frequencies: C9-C18 aliphatic (53%), C11-C22 aromatic (87%), and C19-C36 aliphatic (87%).

Direct Contact Screening Evaluation

Constituents in the surface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs: None
- SVOCs:
 - Benzo(a)anthracene (6 of 15 samples [40% of the samples])
 - Benzo(a)pyrene (11 of 15 samples [73% of the samples])
 - Benzo(b)fluoranthene (8 of 15 samples [53% of the samples])
 - Benzo(k)fluoranthene (3 of 15 samples [20% of the samples])
 - Chrysene (1 of 15 samples [7% of the samples])
 - Dibenzo(a,h)anthracene (7 of 15 samples [47% of the samples])
 - Indeno(1,2,3-cd)pyrene (5 of 15 samples [33% of the samples])
 - 2-Methylnaphthalene (1 of 15 samples [7% of the samples])
 - Naphthalene (1 of 15 samples [7% of the samples])
- Carbon Fractions:
 - C9-C18 aliphatic (2 of 13 samples [15% of the samples])
 - C11-C22 aromatic (5 of 13 samples [38% of the samples])
 - C19-C36 aliphatic (1 of 13 samples [8% of the samples])
- Inorganics:
 - Zinc (1 of 13 samples [8% of the samples])

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figure 3-3B. Note that evaluation of the COI list inorganics was limited to antimony, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, silver, and zinc; for further discussion please see Section 2.3.1.

Migration to Groundwater Screening Evaluation

The concentrations of the carcinogenic compounds in the surface soil samples were compared to the MTGW SLs. Exceedances of the MTGW SLs consisted of the following:

- VOCs: None
- SVOCs:
 - Benzo(a)anthracene (2 of 15 samples [13% of the samples])
 - Benzo(a)pyrene (2 of 15 samples [13% of the samples])
 - 1-Methylnaphthalene (6 of 15 samples [40% of the samples])

The locations at which one or more carcinogenic constituents exceeded the MTGW SLs are indicated on Figure 3-3B.

Comparison to Background Values: Inorganics

Per MDEQ approval, background values for metals in soil have been established for the Facility (see Section 2.3). Note that the approved background concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL and leaching screening levels. Exceedances of the background values consisted of the following:

- Antimony (15 of 15 samples [100% of the samples])
- Arsenic (0 of 15 samples [0% of the samples])
- Barium (1 of 15 samples [7% of the samples])
- Beryllium (0 of 15 samples [0% of the samples])
- Cadmium (9 of 15 samples [60% of the samples])
- Chromium (2 of 15 samples [13% of the samples])
- Cobalt (0 of 15 samples [0% of the samples])
- Copper (10 of 15 samples [67% of the samples])
- Lead (10 of 15 samples [67% of the samples])
- Mercury (2 of 15 samples [13% of the samples])

- Nickel (0 of 15 samples [0% of the samples])
- Selenium (0 of 15 samples [0% of the samples])
- Silver (4 of 15 samples [27% of the samples])
- Vanadium (0 of 15 samples [0% of the samples])
- Zinc (9 of 15 samples [60% of the samples])

Subsurface Soil Results

Subsurface samples were not collected.

Extended Analyte List for Surface Soil

The program samples were analyzed for the COI list constituents plus other (non-refinery associated) constituents including herbicides/pesticides, PCBs/PCPs, and dioxins as listed on the laboratory reports (Appendix 3-E).

Table 3.9-2 lists the non-COI list constituents that were detected in the program samples. The purpose of the extended analysis was to characterize the types of impacts present on the property; however, Table 3.9-2 also provides direct contact screening level and MTGW screening level (where applicable) exceedances.

Direct Contact Screening Evaluation

The expanded analyte constituents in the surface soil samples exceeding the direct contact SLs consisted of the following:

- VOCs: None
- SVOCs:
 - 3-Methylcholanthrene (1 of 12 samples [8% of the samples])
 - PCB-1254 (1 of 15 samples [6% of the samples])
- Inorganics:
 - Aluminum (12 of 12 samples [100% of the samples])
 - Iron (12 of 12 samples [100% of the samples])
 - Manganese (12 of 12 samples [100% of the samples])
- Dioxins and Furans: None

Migration to Groundwater Screening Evaluation

The expanded analyte constituents in the surface soil samples exceeding the MTGW SLs consisted of the following:

- VOCs:
 - Methylene Chloride (11 of 12 samples [92% of the samples])
- SVOCs:
 - 3-Methylcholanthrene (1 of 12 samples [8% of the samples])
 - Biphenyl (2 of 12 samples [15% of samples])
 - 4-Chloroaniline (1 of 12 samples [8% of the samples])
 - Dibenzofuran (1 of 12 samples [8% of the samples])
 - g-BHC (Lindane) (3 of 15 samples [20% of the samples])
 - 4,4-DDD (4 of 15 samples [25% of the samples])
 - 4,4-DDE (6 of 15 samples [38% of the samples])
 - 4,4-DDT (8 of 15 samples [50% of the samples])
 - Heptachlor epoxide (1 of 15 samples [6% of the samples])
 - MCPA (3 of 15 samples [20% of the samples])
- Inorganics:
 - Iron (12 of 12 samples [100% of the samples])
 - Manganese (12 of 12 samples [100% of the samples])
- Dioxins and Furans: None

3.10 RESIDENTIAL PROPERTIES/BACKFILL SOILS INVESTIGATION

This section discusses investigation activities conducted by CEMC from July through December 2011 at residential properties in Sunburst, Montana, in accordance with the MDEQ-approved work plan entitled, *Residential Soil Investigation Work Plan, Phase II Remedial Investigation, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, dated July 14, 2011 (CEMC 2011a) (“RSI Work Plan”). The results of the investigation are detailed in the entitled *Residential Soil Investigation Summary Report, Former Texaco Sunburst Refinery, Sunburst, Montana* dated May 9, 2012 (CEMC 2012b) (“RSI Summary Report”). Figure 3.10-1 depicts the properties that were included in investigation and also includes properties that were involved in the prior investigations summarized in Section 3.10.1.

Properties are identified based on a grid established for the Town of Sunburst utilizing alpha-numeric block identifiers. The naming convention utilized for samples collected during the RSI is presented in Table 2.1-3 and Section 3.10.2 of this Report, and presented in detail in Section 2.3 of the RSI Summary Report.

MDEQ provided comments on the RSI Summary Report via correspondence dated July 31, 2012. These comments are addressed in the following sections, which present key aspects of the RSI Summary Report and the conclusions therein.

3.10.1 PRIOR RESIDENTIAL SOIL INVESTIGATIONS

A detailed history of prior investigations involving residential soil is presented in Section 1.1 of the RSI Work Plan (CEMC 2011a). In late 2007, CEMC learned soil had been removed from one of the former refinery tank berms (Tank Berm 3) by a resident and used as backfill around a home, which was constructed within the perimeter of another tank berm (Tank Berm 34). Figures 3-1 and 3-2 depict the locations of tank berms associated with the former refinery. The proximity of the residence to Tank Berm 34 can be seen on Figure 3.4-1. A sampling effort was conducted in March 2008, and from this effort it was determined that lead was present at a concentration above the residential screening level of 400 mg/kg in some of the soils surrounding the residence. At MDEQ's request, CEMC developed a work plan to further characterize soils surrounding the residence and remove/replace those soils containing lead at concentrations above the RSL. This latter effort was conducted between November 2008 and April 2009.

During late 2009/early 2010, CEMC was informed that soils originating from tank berms on the former refinery were present on four separate properties within the Town of Sunburst. These properties are depicted as H1-P2, H1-P3, P5-P3 and U1-4 on Figure 3.10-1. According to information provided to CEMC by the four property owners, soils were removed from the following tank berms for use as backfill material:

- Tank Berm 34. Soils from Tank Berm 34 were placed on two adjoining parcels of property as backfill around a workshop building and residence, H1-P3 and H1-P2, respectively.
- Tank Berm 20. Soils from Tank Berm 20 were used as backfill on a third property, U1-4 to raise the ground surface level beneath the gravel driveway.
- Tank Berm 19 or 29. A fourth property owner, P5-P3, indicated soils from “the tank berm next to the county road” were used as backfill within the basement of a former structure that was demolished by owner. Tank Berms 19 and 29 are located closest to the county road, making them the likely source. Tank Berm 19 was sampled during the field work conducted to update the CSM. Soils and hydrocarbon residual sludge were removed from Tank Berm 29 during the VCP activities and placed in a stabilized waste landfill; the footprint of Tank Berm 29 is located under that stabilized waste landfill constructed during VCP activities, and is inaccessible.

CEMC conducted surface soil sampling at the four properties during February 2010 in accordance with the procedures described in the CSM Work Plan. A total of 29 individual locations were sampled at the four properties to characterize the borrowed tank berm soil. Analytical results indicate that four soil samples exceeded the USEPA residential soil RSL for lead. Those four samples were collected from two individual locations, located on each of the two adjoining properties that utilized soils from Tank Berm 34 as backfill. Analytical results indicate that four soil samples exceeded the USEPA residential soil RSL for lead. CEMC presented these findings to MDEQ via correspondence dated June 4, 2010 entitled “*Soil Sampling Results and Work Plan for Remedial Action, Former Texaco Sunburst Works Refinery, Sunburst, Montana*” (CEMC 2010e).

The remedial activities presented in the June 4, 2010 document were performed in November 2010. During completion of these activities, CEMC was informed of another property, I1-P2, also containing backfill soil that was originally located in a tank berm on the former refinery. Further investigation revealed the original property owner/builder obtained the backfill soils from Tank Berm 34, formerly located on refinery property, but privately owned at the time soils were borrowed. CEMC requested permission to conduct field screening of the soil. With the approval of the property owner, CEMC conducted field screening with hand-held XRF analyzers and collected surface soil samples from six locations on the property. The results of the field screening indicated that lead was present in some of the backfill soils at a concentration exceeding the USEPA RSL. A plan to delineate the extent of lead in soils at this residence was submitted to MDEQ via correspondence dated November 29, 2010, entitled “*Soil Sampling Work Plan for Remedial Action, Former Texaco Sunburst Works Refinery, Sunburst, Montana*” (CEMC 2010h). The activities outlined in that document were performed in December 2010.

Concurrent with the December 2010 residential soil sampling activities, CEMC interviewed several individuals familiar with historical construction-related activities within the Town of Sunburst and was told about a number of other properties that utilized soils from the former refinery as backfill. Due to the presence of soil from the former refinery on these properties, and potentially others, MDEQ requested CEMC develop a more formal, comprehensive work plan to investigate the possible extent of refinery-related soils on properties throughout the Town of Sunburst.

CEMC expanded interviews with Sunburst residents and Town of Sunburst personnel to obtain additional information regarding the extent to which refinery soils may have been used as backfill on properties in town. That information was used, in part, to prepare the RSI Work Plan, which CEMC submitted to MDEQ on June 15, 2011. MDEQ provided comments on the work plan via correspondence dated June 28, 2011. CEMC revised the RSI Work Plan per MDEQ comments and resubmitted the document to MDEQ July 14, 2011. MDEQ approved the work plan via email correspondence dated July 18, 2011.

3.10.2 INVESTIGATION APPROACH AND SAMPLING METHODS

The overall objective of the Residential Soil Investigation was to assess the extent, if any, of impacted soils at residential properties which MDEQ or CEMC determined to contain borrowed soils taken from tank berms in the former refinery. These activities were conducted on properties known or suspected to contain backfill soils, regardless of the source, and other properties in town that were selected on a random basis.

Investigation Approach

Based on the prior investigation activities described in the previous section, lead was determined to be the primary constituent of concern. In those instances, impacted soils from refinery tank berms exhibited significantly elevated levels of lead widely distributed throughout the property and at multiple depth intervals. For this investigation, levels of lead detected, the extent of detection, and the depth detected in relation to the depth of backfill, were key factors in determining whether soil impacts originated from the former refinery. Although SVOCs are less of an indicator, analysis for and the evaluation of SVOCs and EPH were included in the investigation objective, as these compounds have been detected at concentrations exceeding screening levels in surface soils located on former refinery property.

CEMC conducted a number of assessment activities prior to and during preparation of the RSI Work Plan in order to better define and focus investigation efforts. These activities are discussed in detail in Section 2.1 of the RSI Work Plan. Several assumptions had been made prior to the start of assessment activities, a significant one being the assumption that backfill soils were widely used around town, with the likely source of those soils being the former refinery. Section 2.1 of the RSI Work Plan provides a detailed listing and description of these assumptions.

The assessment process included the review of information obtained from interviews with residents and public officials. More than two dozen individuals were interviewed between December 2010 and May 2011. Additional interviews were conducted immediately prior to the start of and during sampling activities as other residents came forward to request soil sampling on their property.

As a result of the interviews, CEMC acquired more information about potential and known backfill activities and modified some of its original assumptions. Most significantly, use of refinery soils as backfill appears to not be as widespread as reported during initial interviews. Instead, the taking of soils from tank berms at the former refinery since its closure in 1961 appears to have been conducted by approximately half a dozen individuals, primarily private property owners with tank berms on their property, and/or individuals with personal or professional relationships with those private property owners. Also, evidence suggests that only four of the former tank berms were used as sources of backfill soil, with a limited volume (approximately 5,000 cubic yards) removed. Of those four berms (3, 19, 20, and 34), CEMC has information from the individuals who hauled the soil about the locations where the dirt was placed

from three of the berms (3, 20, and 34). Other key information obtained during these later interviews, and the overall assessment process, are presented in detail in Section 2.2 of the RSI Work Plan.

Following completion of the assessment process, CEMC then developed categories for properties which had the potential to have refinery soil. In addition to sampling properties known or suspected to contain backfill soils, MDEQ requested CEMC conduct random sampling throughout the Town of Sunburst in order to verify that refinery soils have not been used as backfill on a more widespread basis than what had been reported. This resulted in properties being classified in one of four categories, as follows:

- Property contains backfill soils from the former refinery – shaded red on Figure 3.10-1
- Property contains backfill soils from an unknown source – shaded yellow on Figure 3.10-1
- Property contains backfill soils from a source other than the refinery – shaded green on Figure 3.10-1
- Property selected as part of a random sampling program – shaded blue on Figure 3.10-1

Properties for random sampling (blue shading) were selected by laying an approximate 300 foot by 300 foot grid over the entire town, similar to that utilized for the Facility, described in Section 2.1.4. One block within the town is roughly equivalent to one 300 foot by 300 foot grid cell. One property was selected from each block that contained no other properties selected for sampling as described above. Properties were selected for random sampling with consideration of a number of criteria, described in Section 2.2.2 of the RSI Summary Report.

Properties planned for inclusion in the residential soil investigation based on the above categories were originally depicted in the RSI Work Plan. Following MDEQ’s approval of the RSI Work Plan and/or the start of the Residential Soil Investigation, additional residents requested their properties be included in the investigation. The requests continued throughout the duration of the investigation, with the last request being received in August 2012. In most cases, these properties were not known to contain backfill and were added to the random sampling portion of the investigation. In a few instances, property owners did indicate backfill soils were present on their properties. Since these residents had not come forward during prior multiple prior requests from MDEQ and CEMC for more information regarding the use of refinery soils as backfill, it was assumed in these instances the backfill soils originated from an unknown source. Data generated during the investigation, discussed further in Section 3.10.5, suggest these backfill soils did not originate from the refinery, affirming residents’ statements collected during the interview process.

Properties included in the investigation are shown on Figure 3.10-1. Note that the terms “parcel” and “property” are used interchangeably throughout this document to denote the individual rectangles appearing on the figure. An individual residence or business (home, garage, outbuildings, yard, etc.) may be comprised of one or more properties.



For example, the residence located at the SE corner of Main Street and 3rd Avenue West is comprised of two properties (or parcels), J3-P3 and J3-P4.

At the request of MDEQ, CEMC also conducted sampling on a stockpile of soil and other material located on the northeast side of the Town of Sunburst, east of the ball field. The property and the stockpile are owned by the Town of Sunburst. As mentioned in the work plan, this stockpile has uncontrolled access and is commonly known as a depository and borrow area. There is a possibility the stockpile may contain refinery soil. However, there is also potential that it contains impacted materials and soils that did not originate from the refinery. For example, during the 2011 RSI activities, the Town of Sunburst was resurfacing the roadways and while doing so, placed both roadway materials and debris in the stockpile area. This was noted on the stockpile sampling field form and in accompanying photographs, presented in Appendix 3-B and 3-G, respectively.

A bi-level approach was used to conduct the Residential Soil Investigation. Proposed screening and sampling methods were the same for both levels of the program, with the primary difference being how each property was broken down for sampling.

- For properties known or assumed to contain backfill soils from the former refinery (shaded red on Figure 3.10-1), or an unknown source (shaded yellow on Figure 3.10-1), a sampling grid comprised of 25-foot by 25-foot cells was established over the entire property; unless the property owner specified the exact location of the backfill area. A boring was taken from each cell of the grid and the resulting soil core screened/sampled in accordance with the procedures described in Section 3.2.1 of the RSI Work Plan.
- For properties with backfill soils from a known source other than the refinery (shaded green on Figure 3.10-1) or those randomly selected for inclusion in the investigation (shaded blue on Figure 3.10-1), sampling zones were established on these properties, in accordance with the USEPA Region VIII document *Draft Final, Residential Soil Lead Sampling Guidance Document*, April 2000. Soil borings were placed in three to five locations within each established zone and screened/sampled with the same procedures discussed in Section 3.2.1 of the RSI Work Plan.

Pre-Sampling Planning and Assessment

A grid for the Town of Sunburst was established consisting of alphanumeric block identifiers and separate identifiers for properties within each identified block (Figure 3.10-1). This grid was utilized in the naming convention of samples collected under these two approaches. For example, the property listed as H1-P1 is broken down as follows:

- H1 (the first alphanumeric character)
 - H – Identifies the northern half of a series of city blocks that run east/west
 - 1 – Identifies the position (from west to east) of the particular block of interest (in this case, blocks with an H identifier)
- P1 (the second alphanumeric character)
 - P – Parcel
 - 1 – Identifies the parcel position (from west to east)

Using this logic, H1-P1 details the furthest west parcel of the furthest west block with an H identifier.

For the properties sampled using a grid (red or yellow shaded properties on Figure 3.10-1), the sample ID consists of the property/parcel identifier (with the dash removed for simplicity), followed by an alphanumeric grid cell identifier, and finally an alphanumeric identifier detailing the type of sample and number within the identified cell. Also, a depth identifier was included at the end of each sample ID to denote the depth range from which the sample was taken. For example, sample location H1P1-A02-DP01 (0.5-1.0) would be broken down as follows:

- H1P1 – Details the property/parcel as described above
- A02 – The letter A denotes the column identifier in the grid layout, and the numeral 02 denotes the row identifier in the grid layout
- DP01 – The DP denotes Direct Push (details the use of a direct push sampling technique) and the 01 identifies the boring number from the particular cell (in this case, boring number 1 from cell A02)
- (0.5-1.0) – Indicates the depth range that the sample was taken from (this sample was taken from 0.5 to 1.0 feet below ground surface)

Therefore, H1P1-A02-DP01 (0.5-1.0) describes boring number 1 taken from cell A02 on property H1-P1 from a depth of 0.5 to 1.0 ft-bgs below ground surface.

For properties that were sampled by zone (shaded green or blue on Figure 3.10-1), the sample ID consists of the property/parcel identifier, followed by an alphanumeric zone identifier, and lastly an alphanumeric identifier detailing the type of sample and number. As above, a depth interval is specified after the last alphanumeric character. For example, sample location H2P3-SZ01-DP03 (0.5-1.0) would be broken down as follows:

- H2P3 - Details the property/parcel as described above
- SZ01 – The letters SZ denote Sample Zone (details the property was sampled using zones) and the numeral 01 identifies sample zone number 1
- DP03 – The DP denotes Direct Push (details the use of a direct push sampling technique) and the numeral 03 identifies boring number 3 from the particular zone (in this case, sample zone number 1)
- (0.5-1.0) – Indicates the depth range that the sample was taken from (0.5 to 1.0 feet below ground surface)

Therefore, H2P3-SZ01-DP03 (0.5-1.0) indicates boring number 3 taken from sample zone number 1 on property H2-P3 from the 0.5 to 1.0 ft-bgs interval.

Pre-sampling property assessment, planning and preparation activities are detailed in Section 2.4 of the RSI Summary Report. A significant component of the assessment process was the completion of Residential Soil Questionnaires. An attempt was made to complete Residential Soil Questionnaires for each property included in the Residential Soil Investigation program in order to gain as much background information as possible for each property. Completed questionnaires are presented in Appendix 3-H. One aspect considered during this process was the possibility of impacts from alternate sources, either due to property location or prior activities conducted on a property.

As discussed previously, lead was the primary constituent of interest during this investigation. Elevated levels of lead have been found in soils in several tank berms and tank farm locations on the former refinery site. However, lead also is also present naturally in soil, though at relatively low levels. According to MDEQ, *Background Concentrations for Inorganics in Soil*, the range is from 11.6 ppm to 34 ppm in Montana. Additionally, studies have shown that elevated lead levels in soil can result from several sources, including:

- Point source emitters, such as smelters, batteries, and mine tailings
- Lead-based paint on exterior surfaces, such as building walls
- Leaded gasoline emissions or spills

In rural areas, the more common source for elevated levels of lead in residential soils is lead-based paint (USEPA 1998). Two activities attributed to lead-based paint contributing to soil lead levels were the natural chalking and weathering of exterior lead-based paint, and abatement of the paint using scraping or sandblasting techniques without an attached vacuum collection device.

Soil samples were also submitted for analyses for SVOCs. PAHs are a class of organic chemicals consisting of two or more fused-benzene rings. PAHs can be found in some SVOCs and tend to be more persistent than SVOCs without PAHs. PAHs adsorb very strongly to soils or surfaces, are stable in the atmosphere, and can be transported long distances. The complete COI list for soil is presented in Table 2.1-1. As with lead, there are other, non-refinery sources for SVOCs. Many routine activities have been documented to be sources of SVOCs in soil, including:

- Incomplete combustion of organics (wood, food, plastics, etc.) – Burning of trash or wood, or disposal of charcoal from grills, would result in the presence of PAHs in soils. Smoke can carry particulate PAHs for an extended distance.
- Road paving materials (asphalt, coal tar [commonly used in road construction prior to asphalt]).
- Spillage of hydraulic oil, lube oil, residential fuel oil, and used motor oil – Ground disposal of oils or use in dust control would add PAHs to soil.
- Forest/grass fires (more common in areas prone to fire).

The possibility of impacts from alternate sources of lead and SVOCs were taken into consideration when determining placement of boring locations within a grid cell or sampling zone and during data evaluation, the results of which are summarized in Section 3.10.5.

Sampling Methods

The screening and sampling procedures for the residential soil investigation are described in Section 3.2.1 of the RSI Work Plan, and follow the general methodology described in Section 2.1 of this Report. The focus of this investigation was on surface soils, as information collected on residential questionnaires suggested backfill soils generally were less than 2 ft-bgs. In those instances where backfill soils appeared to be present at depths greater than 2 ft-bgs, the surface soils (0 – 2 ft-bgs) were screened at 0.5-foot intervals, with screening conducted at one-foot intervals for the subsurface soils (greater than 2 ft-bgs). Samples submitted for laboratory analysis were analyzed for lead, SVOCs and EPH.

Investigation activities began in the northwest corner of the Town of Sunburst and proceeded east along Blocks I, H, G, and F (see Figure 3.10-1). Once the properties on those series of blocks were completed, the operation was mobilized to the next set of blocks south, I - J; then K - L, then M - N, and finally O - P.

The investigation extended over a five month period, starting in August 2011 and ending in April 2012, with a total of 27 days of sampling. Several properties were revisited due to laboratory findings. The properties sampled are depicted Figure 3.10-1, which as discussed above, also includes properties sampled during 2010 (H1-P2, H1-P3, I1-P2, P5-P3

and U1-4). Although sampled in 2010, property U1-4 was sampled again during the 2011 residential soil investigation at the request of the owner.

The total number of parcels screened/sampled and samples analyzed during the five month Residential Soil Investigation period is as follows:

- 65 properties were screened/sampled during the investigation. Field forms were completed for each property sampled and are presented in Appendix 3-B.
- 610 primary soil borings were installed over these 65 properties (this number does not include the additional borings installed to collect samples for laboratory QA/QC purposes or additional borings necessary to obtain full recovery for adequate sample material).
- 279 primary soil samples were collected out of the 610 borings (again, this number does not include those samples collected for laboratory QA/QC purposes.
- For laboratory QA/QC purposes, 17 MS/MSD, and 26 blind duplicate samples were also collected.
- A minimum of four screenings per boring location resulted in 2,489 XRF screenings. At properties with backfill greater than 2 feet in depth, soil borings were installed to depth of 4 ft-bgs, which resulted in two additional XRF screenings per boring at those locations.

The Town of Sunburst soil stockpile was sampled following an estimation of the volume of material contained in the stockpile. The stockpile was sampled at a frequency of one 5-point composite sample per 400 cubic yards. Samples were distributed so as to provide a representative range of materials comprising the stockpile. As with the residential properties, samples were analyzed for lead, SVOCs and EPH. Data generated by this effort will be utilized in assessing the source of any soil impacts encountered during the remainder of the sampling program. Note that at the onset of the Residential Soil Investigation, material from the road work that was underway in town was actively being added to one portion of the stockpile. An effort was made to sample “older” areas of the stockpile undisturbed by the more recent activities, as well as the newer material added to the stockpile. These areas are noted on the sampling field form for the stockpile and in accompanying photos, presented in Appendices 3-B and 3-G, respectively.

3.10.3 DEVIATIONS FROM WORK PLAN

There were a few minor deviations from the approved RSI Work Plan during investigation activities, which did not affect the overall investigation results or conclusions. The deviations included:

- Some town blocks exceeded the “one property/block” protocol planned for the random sampling portion of the investigation, as a result of sampling requests from additional property owners while the investigation was underway.
- 25 foot by 25 foot grids were not established for step-out sampling conducted on two properties (P5-P2 and N6-P4) with elevated lead screenings, contrary to the procedures in the RSI Work Plan. Both properties showed a slightly elevated XRF screening result for lead at one location on each property. Samples taken from these locations did not correspond to the depth interval containing the elevated lead screening. For confirmation on the elevated screening, CEMC elected to first return to these properties and resample the proper intervals for lead only. A grid was only established for additional screening/sampling if laboratory analysis confirmed elevated lead, as was the case for N6-P4.
- Sampling 10% of XRF screenings for laboratory confirmation analysis was not performed on all properties. Although most properties met or exceeded this goal, some properties received slightly less than a 10% sample to screening ratio. Typically this occurred on properties selected for random sampling, specifically when the XRF gave no indication for concern. Overall, a 12% sample to screening ratio was achieved throughout the Town of Sunburst.
- Two properties included in the investigation underwent XRF screening only (I1-P4 and K3-P4). In both cases, these properties combined with an adjacent property or properties comprised the overall residence or business location. The location of the structures, property size, and surface materials present on the property made sample collection impractical or unnecessary.
- Prescribed naming convention was not adhered to for one residence (comprised of two parcels, G4-P1 and G4-P2).

Work plan deviations are discussed in greater detail in Section 2.5 of the RSI Summary Report. As noted above, the deviations were minor and did not affect the overall investigation results or conclusions.

3.10.4 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 3-E.

A total of 412 samples consisting of 355 environmental samples, 34 blind duplicates, 18 equipment blanks, and 5 trip blanks, were collected between August 2011 and April 2012. This collection effort resulted in an estimated total of 14,376 sample results including; 12,099 environmental sample results, 1,253 field duplicate sample results, 824 equipment blank sample results, and 200 trip blank results. The results were reported in 45 lab data packages that were



reviewed and validated. The laboratory reports are included as Appendix 3-D; individual validation reports are included in Appendix 3-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 1,366 sample results were qualified as J by the laboratory. Out of these laboratory J flags, 1,051 were preserved during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	1,833
UJ	1,512
JB	27
R	29
TOTAL	3,401

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 3-E. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal met the requirements specified within the QAPP, with the exception of blind duplicates which were not collected at the required frequency. However, these samples are part of a larger project in which field duplicate adequacy is met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	5	1%	1 per cooler*
Equipment Blanks	18	5.1%	5%
Blind Duplicates	34	9.6%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by either SW846 8260B or MA-VPH. Residential samples were not analyzed for volatiles; therefore trip blank samples were not required.

Of the 13,352 environmental and field duplicate sample results reported and validated between August 2011 and April 2012, twenty-seven sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the sampling activities in the residential soil investigation is 99.80%, which is slightly less

than the QAPP required 90%. Most of the rejections were in samples that were not the parent sample but were associated with MS/MSD recoveries. As such, the completeness measure is acceptable.

3.10.5 RESULTS

Due to the nature of the investigation, the data evaluation process for the Residential Soil Investigation utilized a more streamlined approach than described in Section 2.3 of this document. The soil sample analytical results were compared to the most current USEPA RSLs and the MDEQ Tier 1 RBCA Direct Contact SLs for residential surface soil (see Table 2.1-1).

Sixty-five properties were investigated, with samples collected and submitted from 63 properties for laboratory analysis of lead, SVOCs, and EPH compounds. Table 3.10-1 provides a visual summary of sampling results for these properties. Additionally, Figure 3.10-2 depicts sample locations and the spatial distribution of those with lead values exceeding 400 ppm, while Figure 3.10-3 depicts sample locations and the spatial distribution of those with exceedance(s) of RBSLs for SVOC and EPH results combined. Both the table and figures include data generated during the 2010 investigations described in Section 3.10.1. Appendix 3-B contains individual data summaries for each of the 65 properties.

Note that on Figures 3.10-2 and 3.10-3, some sample locations appear to be located outside of parcel boundaries. The ownership grid, shown on the figures, is an approximation of parcel boundaries as depicted by the Montana cadastral map which is based on legal property descriptions. Since legal property descriptions do not include property owner maintenance areas that are within city owned right-of-ways (i.e., the grassy strip located between the sidewalk and the road), some soil borings appear outside of a parcel's boundaries. It is important to note that these locations are actually within the property owner's area of maintenance.

Lead Results

Sixty-five properties were screened/sampled as part of the Residential Soil Investigation. Of those properties:

- Fifty-nine did not have any locations with lead greater than 400 ppm, including nine properties reported to contain backfill soils originating from the former refinery. No further action is planned for these properties.
- One property, H1-P1, exceeded the residential RSL of 400 ppm for lead at multiple locations, via both XRF screenings (15 exceedances) and laboratory data (7 exceedances). This property had been identified as containing backfill soils originating from the former refinery. It is adjacent to two properties (H1-P2, I1-P2), and is one parcel removed from a third property (H1-P3), also identified as containing backfill soils originating from the refinery, all of which were sampled in 2010 and all of which were found to have levels of lead exceeding the residential RSL at

multiple locations and at multiple depth intervals. As with those earlier investigations, the extent and distribution of elevated lead throughout HIP1 was considered indicative of impacted refinery soils. A third adjacent parcel, I1-P1, was identified as also containing backfill soils, although no elevated levels of lead were encountered during screening/sampling activities. Remediation activities in accordance with Section 4.0 of the RSI Work Plan were initiated in 2011 and are expected to be completed in late 2012.

- Five properties contained one location with lead greater than the residential RSL of 400 ppm, as determined by either XRF readings or laboratory analysis. None of these properties had been identified as containing backfill soils originating from the former refinery. Two of the five contain backfill soils from an unknown source. The remaining three were included in the random sampling program. Circumstances and resolution for each parcel varies, as follows:
 - F5-P4 – This property was originally included in the random sampling program. There were no XRF lead screenings at this property above the residential RSL of 400 mg/kg. However, laboratory results indicated lead above the residential RSL (451 ppm) was present at one location. In accordance with RSI Work Plan requirements, a grid of 25 foot by 25 foot was established and the entire parcel screened/sampled, including the area with the prior elevated lead results. During sampling using the grid approach, a piece of painted sheet metal was encountered near the location of the elevated lead sample. The metal was screened with the XRF, resulting in high lead readings. No additional locations with lead greater than the RSL were encountered during this second effort. It was concluded the original elevated lead soil sample was likely due to the presence of materials with lead-based paint, such as the painted sheet metal. No further action is planned for this parcel.
 - H3-P3 – Western portions of this property contain backfill from an unknown source. The remaining backfill consists of soil generated during excavation for the basement of the home located on the property. This property is also adjacent to a property purported to have used refinery soils as backfill (H3-P2). The property was screened/sampled using the grid comprised of 25-foot by 25-foot cells. One location at the western edge of the property had both an XRF screening and laboratory result for lead exceeding the residential RSL. The proximity to an adjacent parcel containing soils originating from the refinery suggested the possibility that impacted refinery soils are present at this one location. Additional sampling conducted in July 2012 indicates that elevated lead concentration is confined to the area within 3-5 feet of the original sampling location. Focused remediation in the form of spot excavation was completed during September 2013 at this property.
 - I2-P3 – This property was reported to contain backfill soils from an unknown source and was therefore screened/sampled utilizing a grid comprised of 25-foot by 25-foot cells. Laboratory results for one location on the north side of the property indicated lead was present at levels greater than the residential RSL. This location is located within a driveway/utility corridor. While there is a remote possibility this could be

attributable to backfill soils originating from the former refinery, the limited and isolated nature of the lead exceedance combined with the location within a driveway area (used for vehicle parking and storage) indicates that likely is not the case. However, in an effort to err on the side of conservatism, focused remediation in the form of spot excavation was completed during September 2013 at this property.

- N6-P4 – This property was included in the random sampling program. The property owner had expressed interest in having the garden area at the south end of the parcel sampled as there was some uncertainty as to the origin of the soil in that area. During the initial screening/sampling, XRF screenings for lead exceeded the residential RSL at two depth intervals in the same soil boring. This boring was not located in the suspect garden area but rather in the northeast corner of the property, adjacent to Railroad Avenue. Laboratory results for the soil sample collected from that same boring location, but at a deeper depth interval, did not corroborate the elevated XRF screenings; the result reported for lead was significantly lower than the RSL. It was decided to re-screen/resample that location and a number of points around it, focusing only on lead. Laboratory results for a sample collected immediately adjacent to the original boring, and at the same depth interval as the original elevated XRF screenings, indicated lead was present at levels greater than the residential RSL. A grid of 25 foot by 25 foot was then established and the entire parcel screened/sampled in accordance with RSI Work Plan requirements. No additional locations were found with lead elevated above the residential RSL. Although there is the remote possibility the elevated lead levels at this one location could be due to the former refinery, the limited and isolated nature of the lead exceedance combined with the location (adjacent to a roadway, near railroad tracks) indicates it likely is not the result of impacted soils originating from the former refinery. However, in an effort to err on the side of conservatism, focused remediation in the form of spot excavation was completed during September 2013 at this property.
- P5-P2 – This property was included in the random sampling program at the request of the property owner, who was concerned about two areas that may or may not contain backfill; one was the site of a former residence demolished/buried in place and the second a former garden area. A hand core sampler was utilized on this property, necessitating the installation of multiple small borings (< 1-inch in diameter) to collect sufficient material to comprise a sample to be submitted for laboratory analysis. In the area of the demolished structure, one of these multiple borings comprising a single “sample location” had an XRF screening value at one depth interval that exceeded the residential RSL for lead. The sample collected from that boring location was collected from a depth interval shallower than the interval with the elevated XRF screening. Laboratory results for that sample did not corroborate the elevated XRF screening; the result reported for lead was significantly lower than the RSL. It was decided to re-screen/resample that location and a number of points around it, focusing only on lead. No additional XRF screenings or the laboratory results for the samples collected exceeded the residential RSL for lead. Given the multiple XRF screenings (collected at the same time, same location, and same intervals) with no readings greater than the residential RSL for lead, it was concluded the

original elevated XRF screening was likely an instrument anomaly. No further action is planned for this property.

- Town of Sunburst Soil Stockpile – No lead exceeding the residential RSL was detected in the locations sampled.

Appendix 8-B to this Report provides relevant information for all of the properties where remediation in the form of excavation of lead impacted soils has been completed to date.

SVOC/EPH Results

Sample data were compared to MDEQ RBSLs for SVOCs/EPH. Figure 3.10-3 depicts sample locations and exceedances of RBSLs for SVOCs (SVOC and EPH results combined). Table 3.10-1 provides a visual summary of sampling results for these properties. It is important to utilize Figure 3.10-3 in conjunction with Table 3.10-1 and the individual property data tables in Appendix 3-B. While Figure 3.10-3 depicts the number of SVOC RBSL exceedances at a location on a property, the specific SVOCs that exceeded RBSLs may or may not vary between locations. For example:

- Property N5-P1 contains two locations at which 1 – 3 SVOC RBSLs were exceeded. There were a total of five exceedances involving three different SVOCs; benzo(a)pyrene and dibenzo(a,h)anthracene exceeded RBSLs at both locations while indeno (1,2,3-cd)pyrene exceeded the RBSL at one location.
- Property N6-P4 contains four locations at which SVOC RBSLs were exceeded. There were a total of 11 exceedances involving five different SVOCs; benzo(a)pyrene exceeded the RBSL at all four locations, dibenzo(a,h)anthracene at three locations, benzo(b)fluoranthene at two locations, and indeno (1,2,3-cd)pyrene and benzo(a)anthracene each exceeded the RBSL at one location.
- Property N3-P3 contains three locations at which SVOC RBSLs were exceeded. There were a total of three exceedances involving only one SVOC; benzo(a)pyrene exceeded the RBSL at each of the three locations.

It is therefore possible that a property containing two locations at which one to three SVOC RBSLs were exceeded could contain as many as six different SVOCs comprising those exceedances. This was a consideration in evaluating SVOC distribution patterns.

Of the 63 properties from which samples were collected and submitted for laboratory SVOC/EPH analyses during the Residential Soil Investigation:

- Thirty-four parcels had no soil samples that exceeded MDEQ RBSLs.

- Twenty parcels had between one and three SVOCs that exceeded RBSLs.
- Six parcels had between four and six SVOCs that exceeded RBSLs. One parcel also exceeded the RBSL for EPH at one location.
- Three parcels had more than six SVOCs that exceeded screening levels. One parcel also had two exceedances of the RBSL for EPH. A second parcel exceeded the RBSL for EPH at one location.
- RBSLs were exceeded at four locations in the Town of Sunburst soil stockpile.

The most commonly detected SVOCs were:

- Benzo(a)pyrene – found in coal tar, charred organic material, automobile exhaust (especially diesel fuel)
- Dibenzo(a,h)anthracene - by product of fuel burning coal, tar, oil, wood
- Indeno (1,2,3-cd)pyrene - by product of fuel burning coal, tar, oil, wood
- Bis(2-ethylex1)phthalate - hydraulic fluid (dielectric fluid in electrical capacitors); also used in rubbing alcohol, liquid detergents, decorative inks, munitions, industrial and lubricating oils

The properties with more than six SVOCs exceeding RBSLs (N6-P4, H4-P1 and F5-P4) are located adjacent to the more heavily traveled roads in town and/or the area comprising the former business district, which was much larger during the period the former refinery was operational. However, there are few clear-cut patterns that emerged from the sampling results. The distribution of SVOCs is widespread, with SVOCs exceeding RBSLs at multiple properties, both with and without known backfill present. As some locations, activities that were underway during the sampling (adjacent road work, a residence being re-roofed) had the potential to contribute SVOCs to property soil. The spatial distribution as depicted on Figure 3.10-3 does not indicate a correlation with any one particular source, particularly given the many possible alternate sources for SVOCs. The first three SVOCs listed above are PAHs. As previously discussed, PAHs are formed/created from incomplete combustion. These are also considered high molecular weight PAHs and are considered to be very persistent in the environment because of their low solubility in water. In consideration of these factors, no further action is planned based on SVOC data.

3.10.6 CONCLUSIONS

Information obtained during interviews associated with earlier residential investigations conducted during 2010 suggested the use of refinery soils as backfill on properties was a common and widespread practice throughout the Town of Sunburst. This assertion prompted MDEQ to request the comprehensive Residential Soil Investigation summarized in this document. Including those properties investigated during 2010, fifteen properties had been identified as containing backfill soil originating from the former refinery, with all available information indicating

borrowed soils originated from four locations (Tank Berms 3, 19, 20, and 34) at the former refinery. Nineteen properties had been identified as containing backfill soils from an unknown source and four as containing soil from a source other than the refinery. Based on the results of this investigation and those conducted during 2010:

- Only four (H1-P1, H1-P2, H1-P3 and I1-P2) of the 14 properties, identified as containing backfill soils originating from the former refinery, exhibited impacts.
 - Lead was the constituent of interest. Impacts were based on levels of lead significantly greater than the residential RSL of 400 mg/kg, and found at multiple locations and multiple depth intervals.
 - These four parcels are all located on the same block in the northwest portion of town.
 - These same parcels did not exhibit levels of SVOCs exceeding MDEQ RBSLs.
 - Soils containing lead at a concentration greater than the EPA RSL have been removed from these four properties. Appendix 8-B to this Report summarizes the soil remediation activities performed at these properties.
- Two properties identified as containing backfill soils from an unknown source had one location where lead exceeded the residential RSL (H3-P3 and I2-P3).
 - The lack of widespread elevated lead suggests these backfill soils are not impacted soils from the refinery. However, H3P3 is located adjacent to a property purported to have received refinery soils.
 - These same parcels did not exhibit levels of SVOCs exceeding MDEQ RBSLs.
 - In September 2013, CEMC removed and replaced soils containing lead at a concentration greater than the EPA RSL at H3P3 and I2P3. Appendix 8-B summarizes the soil remediation activities performed at these properties.
- No properties containing backfill soils from a source other than the refinery exhibited lead greater than the residential RSL, or SVOCs greater than the MDEQ RBSL.
- Three properties included in the random sampling portion of the Residential Soil Investigation exhibited lead greater than the residential RSL.
 - In the case of two properties, the elevated lead was determined to be the result of an equipment/procedural anomaly (P5-P2) or another source buried in the soil (F5-P4 and P5-P2).
 - Lead was found to exceed the EPA RSL at one location on the third property (N6P4). The lack of widespread distribution of elevated lead concentration suggests the one location on the third property (N6-P4) was not due to impacted soils from the refinery. However, in an effort to err on the side of conservatism, focused

remediation in the form of spot excavation was completed during September 2013 at this property, as detailed in Appendix 8-B to this Report.

- Multiple SVOCs greater than MDEQ RBSLs were found at two properties (F5-P4 and N6-P4); the location of each property (adjacent to the more heavily used streets in town) suggest alternate sources for SVOCs observed.

The overall conclusions drawn from the results of the Residential Soil Investigation are that use of refinery soils as backfill was not widespread, only a portion of the refinery soils utilized as backfill exhibit impacts, and the constituent of concern in those impacted soils is lead.

3.11 LEAD XRF/LABORATORY DATA CORRELATION

As requested by MDEQ in their comments on the CSM Update Report and CSM Update Addendum, CEMC performed additional analysis on the validity of using a portable XRF unit as a field screening instrument for total lead concentration. CEMC previously discussed the correlation between the XRF and laboratory results using two methods. The first method was completed by directly comparing the XRF results to the lab results using a best fit linear line. The corresponding coefficient of determination (R^2) was presented as 0.74 indicating a positive correlation. The second comparison split the figure into quadrants and detailed the reliability of the XRF as a field screening instrument for determining areas of concern.

CEMC has chosen to focus on the second method of comparison due to known limitations of the XRF, including: interference created by other inorganic constituents, soil moisture, and an inability to properly homogenize sampled intervals in the field (typically due to gradation and moisture). The factors described above change drastically based on the type of soil, location of soil, and the time of year. Standardizing these different aspects would be difficult, which creates a significant problem when looking at the data using a direct comparison method (including coefficient of determination, and relative percent difference). However, the purpose of the XRF is to determine areas of concern based on the EPA RSL for total lead of 400 mg/kg. The quadrant method gives an accurate depiction of the entire data set and a good representation of the XRF's reliability.

Figure 3.11-1 illustrates the field screened XRF value and the associated lab result. Please note that a logarithmic scale was used to help consolidate data on the figure. There are two possible outcomes when a soil sample is screened with the XRF. The XRF either details that no lead was detected in the sample less than an indicated number (detection limit), or it gives you a detection result in ppm. For all values not detected (ND), the number plotted is the detection limit vs. the lab result; these results are indicated by the red squares on the figure. For all XRF detections, the number plotted is the detection result vs. the corresponding lab result; these results are indicated by the blue diamonds. Also



plotted on the figure is a concordance line showing where the points would fall if the XRF was 100% accurate. Additionally, lines are plotted representing the MDEQ RBSL of 400 mg/kg and the CEMC determined action level of 280 ppm for the XRF, effectively breaking the figure into quadrants.

During the course of the Phase II RI, CEMC chose an action level of 280 ppm lead to indicate cause for concern. This action level was based on manufacturer and general literature discussing the effectiveness of portable XRF units for field screening purposes and a percentage of error that had been observed with the use of XRF equipment that could range as high as 30%. More specifically, CEMC elected to take confirmation samples from every XRF screening that was greater than 280 ppm and less than or equal to 400 ppm; the objective being to diminish the effect of the XRF's limitations by providing a 30% buffer from the RBSL.

Since September of 2009, CEMC has collected, field screened, and submitted 1088 soil samples for total lead analysis, 1,018 of the 1,088 were screened below the action level of 280 ppm, 31 were screened between 280 ppm and 400 ppm, and 39 were screened at or above 400 ppm. Out of the 39 screened above the RBSL, 29 were confirmed by laboratory results while 10 indicated that the XRF had given a false positive. Of the 1018 samples screened below the action level, 1,005 of them produced a lab result below the MDEQ RBSL, yielding reliability rate of 98.7%. The remaining 13 have been categorized as 'false negatives' because the XRF indicated no concern but the lab produced results greater than the RBSL. Sample IDs associated with the false negatives and false positives can be seen in Table 3.11-1. Additionally, the false negatives appear in quadrant II of Figure 3.11-1 while the false positives are seen in quadrant IV. The remaining 31 samples screened between the action level and the RBSL (in the buffer zone) produced 17 lab results less than the RBSL and 14 RBSL exceedances.

Reviewing these results has produced two items of significance. The first is the importance of the action level. By gathering information on the limitations of the XRF and creating a buffer region to account for those limitations, the reliability rate of the XRF increased from 97% to 99%. The second is affirmation of the XRF's purpose, which is the ability to look at a screening result less than the action level and have a 99% confidence level that the result is less than the RBSL. CEMC plans to continue using the XRF as a field screening instrument while understanding the importance of lab verification.

4.0 GROUNDWATER INVESTIGATION RESULTS

As part of the Phase II RI, CEMC committed to collecting additional data sets to further characterize the conceptual understanding of geology, hydrogeology, and the nature, degree, and extent of impacts that exist on and adjacent to the Facility (i.e., further delineation of known occurrences of LNAPL at the Facility). Investigation activities were designed to address specific groundwater concerns and data gaps identified in MDEQ's May 16, 2008 SOW on an area by area basis. Investigation approach and methodologies were detailed in the CSM Work Plan and the Phase II RI Work Plan, with the ultimate goal being to delineate the extent and movement of both LNAPL and dissolved-phase constituents present at the Facility. To this end, CEMC completed the installation of 89 new shallow monitoring wells, 45 deeper monitoring wells, and 5 hydrocarbon recovery wells during the course of the Phase II RI.

Subsurface investigation activities related to the groundwater portion of the Phase II RI were conducted in two stages, with information and data collected during the first stage used to formulate the approach for the second stage of investigation activities. Groundwater investigation activities began in December 2009, and were conducted in accordance with the approach and procedures outlined in the CSM Work Plan. This first stage of monitoring well installation was completed in January 2010, and consisted of the completion of 25 shallow and 7 deep monitoring wells. Results of the first stage of groundwater investigation activities were presented in the CSM Update and CSM Addendum documents. These results were used to define the second stage of groundwater investigation activities, as outlined in the Phase II RI Work Plan. The second stage of monitoring well installation was conducted between September 2010 and November 2011, and consisted of the completion of an additional 64 shallow monitoring wells, 38 deep monitoring wells (11 of which were deep-fracture wells), and 5 hydrocarbon recovery wells.

As discussed in Section 2.1.4 of this document, naming conventions were established for samples collected during Phase II RI activities, the purpose being to distinguish Phase II RI samples from those collected during prior investigations. The complexity of the naming convention is related to the media sampled and in the case of groundwater investigation activities, that complexity was enhanced by the need to utilize wells installed during prior investigations, as detailed in Section 4.1. Wells associated with the Phase II RI; therefore, were designated with different nomenclatures to help specify well installation time or purpose, as follows:

- Wells with a "P2RI" prefix (Phase II RI) followed by a number, with "S", "D", or "DF" suffix. The suffixes signify a shallow, deep, or deep-fracture well, respectively. Examples include P2RI-27S, P2RI-45D, and P2RI-47DF.
 - In some cases more than one well was installed at a location in order to evaluate the shallow, deep, or deep-fracture zone. In these cases a "U", "M", or "L" suffix was added to the primary well designation suffix (e.g.,

P2RI-54SU, P2RI-54SM, P2RI-54SL). In this example, three separate monitoring wells were installed in separate, distinct saturated zones within the upper, middle, and lower portions of the shallow alluvial sediments.

- Wells installed to replace open-hole sonic borings installed during 2007 at the Facility are identified with a “GW” prefix, followed by the sonic boring’s identifier. Examples include GW-H (monitoring well installed to replace the open hole sonic boring “H”), and GW-C-29 (monitoring well installed to replace the open hole sonic boring “C-29”).
 - As above, in some cases more than one well was installed at an open-hole sonic boring location in order to evaluate different zones of the subsurface (shallow, deep, or deep-fracture). For example, at open hole sonic boring M, a monitoring well was installed in the shallow interval (GW-MS) and a separate well was installed in the deep-fracture zone (GW-MDF).

The following sections detail the approach and methods utilized to conduct groundwater investigations associated with the Phase II RI, and present the results of those investigations. Monitoring well locations are shown on Figure 4.1-1 and in Table 4.1-1. The locations of other monitoring wells installed prior to the Phase II RI are also shown for reference.

4.1 SUMMARY OF PREVIOUS INVESTIGATIONS

As summarized in Section 1.4.2 of this document, numerous investigation activities have been conducted since 1989 to characterize the nature and extent of groundwater impacts at the Facility. Results of each investigation activity have been used to assist in formulating the current CSM. The following sections summarize the historical investigations as well as the results of the recent Phase II RI. Activities, results, and recommendations for future assessment activities are discussed as they pertain to the development and understanding of the Facility’s current CSM (Chapter 7.0).

The following groundwater investigation activities have been completed by CEMC and its predecessors at the Facility since 1989, and leading up to the Phase II RI:

- Installation of 34 monitoring wells (denoted by GW-prefix). Many of these wells are currently included as part of the Facility’s routine quarterly groundwater quality monitoring program.
- Construction of 53 temporary monitoring wells (denoted by LSSI- and PA-prefix) during 2006-2007, primarily on the former refinery property to determine soil and groundwater conditions at the Facility in areas not previously assessed. Many of these wells were sampled one time after installation to determine the nature and degree of refinery-related impacts to groundwater.

- Construction of 23 observation wells, to assess efficacy of multi-phase extraction (MPE) pilot testing activities completed in 2001 and 2006 (denoted by PT- and PTA-prefixes).
- Installation of 100 soil borings during several investigations at both the former refinery site and within the Town of Sunburst between 1999 and 2007 (denoted by AD-, PD-, PD2-, D-, and SI-prefixes).
- Installation of 21 “deeper” soil borings by sonic drilling methods at the former refinery site and within the Town of Sunburst as part of the 2006-2007 LSSI activities. These borings were denoted with C-prefixes and a number (for example, boring C-29), or a single letter [A – N] (for example, boring M).

CEMC has pursued multiple strategies to characterize the bedrock fracture and joint systems at the Facility, and to determine how fractures influence contaminant migration. Those strategies have included:

- Completion of borehole geophysical and hydrophysical surveys to characterize subsurface geologic and hydrogeologic conditions
- Evaluation of data from drilling locations to identify the presence/absence of LNAPL at the Facility
- Evaluation of forensic chemical analyses of LNAPL and groundwater samples from numerous Facility locations
- Evaluation of data collected by third parties regarding the presence/absence of LNAPL at the Facility

In addition to the above, CEMC also currently conducts the following long-term routine monitoring programs at the Facility related to groundwater and contaminant migration:

- Site-wide quarterly groundwater elevation monitoring (Table 4.1-2).
- Monthly LNAPL thickness monitoring and recovery (if applicable) at selected monitoring wells (including those installed by CEMC and those installed by WET).
- Groundwater quality monitoring. Note that prior to 2013, CEMC conducted quarterly monitoring within the Town of Sunburst. In the second quarter 2013, CEMC began groundwater monitoring in accordance with the MDEQ-approved work plan entitled *Groundwater Sampling Program Modification* (CEMC 2013b, included as Appendix 4-J), which includes semiannual monitoring of groundwater quality at 83 wells located within the Town of Sunburst and the former refinery property.

Each investigation listed above has served to further enhance the Facility’s CSM. The most significant investigation and data collection activities related to groundwater and leading up to the Phase II RI were the LSSI (February 2006 to May 2009) and the Supplemental Pilot Test (September to November 2006). Based upon data gathered during the



LSSI and Supplemental Pilot Test activities, other refinery-related releases and constituents within and around the originally defined groundwater plume area (and not related to the 1955 gasoline release) were discovered.

CEMC submitted an addendum to the Revised LSSI Work Plan on August 10, 2007, proposing additional investigative work. The proposed activities were designed to further characterize the nature, degree and extent of refinery-related petroleum hydrocarbon in soil and groundwater at the Facility, and contribute to the conceptual model of the site with regards to subsurface geology, hydrogeology, and distribution of Facility-related impacts, including potential groundwater and hydrocarbon migration pathways.

During August and September 2007, twenty-one open-hole, continuous core sonic borings were installed at the Facility and within the Town of Sunburst. The total depth of the sonic borings ranged from 46 to 136 ft-bgs, with each boring terminating at an elevation of approximately 3,330 ft-amsl. Completing each boring to this elevation allowed examination and investigation of deeper levels of the subsurface than had previously been investigated at the Facility. Seven of the sonic borings (C-24, C-25, C-29, C-45, C-46, C-47, and C-48) were installed at the approximate locations of investigation or recovery wells installed by Texaco during its 1955-1957 investigation of the gasoline pipeline release (summarized in Section 1.4.1 of this document).

Geophysical and hydrophysical logging were conducted in select borings between October 2007 and May 2008. The methodologies and selected locations for the tests were in accordance with MDEQ-approved procedures described in the August 10, 2007 addendum to the Revised LSSI Work Plan (CEMC 2007a). CEMC contracted RAS, Incorporated (Golden, Colorado) to perform geophysical logging surveys at borings A, C, C-25, C-45, C-46, C-47, C-48, D, E, G, I, L, M, and N. Hydrophysical logging, which requires filling of the borehole with de-ionized water and measuring physical and chemical properties of inflowing groundwater, allowed for investigation of hydrologic zones, evaluation of connectivity between zones, characterization of ambient flows (if present), and estimation of hydraulic conductivities. Hydrophysical logging was completed at borings A, C, C-25, C-46, C-47, C-48, E, L, M, and N. The geophysical and hydrophysical logs and more detailed information regarding methodology and interpretation of results are provided in the June 30, 2009 submittal entitled *Geophysical and Hydrophysical Logging Activities Summary Report: Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2009c) (“Geophysical Summary Report”).

Collectively, the geophysical and hydrophysical data indicate that groundwater flow (and therefore contaminant migration) beneath the Facility is highly complex. Generally, the geophysical and hydrophysical data indicated water-bearing zones at different depths, with the potential for communication between the zones. The pattern of hydraulic conductivities may be a result of linear features crossing the Facility; such features logically could act as flow paths,

but the data are too sparse to clearly identify their continuity, direction, and significance. The acoustic televiewer logs, in conjunction with other geophysical logs and hydraulic conductivity distributions, suggested that there may be structural trends across the Facility that play an important role with respect to potential migration of LNAPL and dissolved constituents. Information provided by the geophysical and hydrophysical surveys was utilized in the determining the location and terminal depth of monitoring wells during the Phase II RI, and is incorporated into the CSM (Section 7.1).

As stated previously, the results of each investigation activity summarized above were used to assist in formulating the current CSM. Additionally, information gathered from these prior investigations were used to define the objectives of the Phase II RI groundwater investigation and determine the investigation methods necessary to meet those objectives. These are discussed in the following sections.

4.2 PHASE II RI GROUNDWATER INVESTIGATION OBJECTIVES AND METHODS

A significant number of soil borings and groundwater monitoring wells have been installed during the completion of subsurface investigations at the Facility, and the information and data collected have provided greater understanding into the complex geologic and hydrogeologic environment that is present. Extensive physical and chemical data collected prior to the Phase II RI indicated that the presence and movement of groundwater and contaminants at the Facility occur primarily within the shallow subsurface (i.e., to a depth of approximately 40 ft-bgs), and especially within the upper zone of weathered, fractured shale. However, data gaps continued to exist in understanding the complex subsurface environment at the Facility. Gaining a better understanding of the presence or absence of Facility-related contaminants in the subsurface throughout the entirety of the Facility, and especially the degree of connectivity between those subsurface zones where groundwater and/or contaminants are present, are critical components of advancing the development of the Facility's CSM.

As previously discussed, CEMC proceeded with the Phase II RI in a two-staged approach. The following subsections provide a brief summary of the first stage of the Phase II RI, which describes the investigation goals as well as the results which were used to develop the second groundwater investigation stage of the Phase II RI.

4.2.1 FIRST STAGE OF PHASE II RI GROUNDWATER INVESTIGATION

Through the evaluation of historical physical and chemical data as well as the geophysical and hydrophysical investigation results, CEMC identified data gaps in its understanding of the complex subsurface environment at the Facility. To begin to address those data gaps, CEMC in the CSM Work Plan proposed installation of additional shallow groundwater monitoring wells at the Facility, with the following objectives:

- To provide further information on the nature, degree, and extent of Facility-related contaminants present in the shallow subsurface
- To gain a better understanding of the thicknesses of the weathered, highly fractured shale zone, and the overlying unconsolidated sediments
- To provide a better understanding of the variability within groundwater bearing zones at the Facility
- To attempt to define the degree of connectivity between those water-bearing zones
- Identify possible sources of Facility-related impacts, including potential hydrocarbon migration pathways to groundwater
- To better define any areas requiring further investigation

4.2.1.1 SUMMARY

A detailed presentation of the first groundwater investigation stage was presented in the CSM Update and CSM Addendum. Below is a brief summary of the findings of that investigation as they pertain to the Facility's CSM.

- Consistency with Updated Conceptual Site Model: Soil and groundwater data collected during and after installation of the Phase II RI groundwater monitoring wells were consistent with the CSM, i.e., the constituents detected in soil and groundwater samples collected from the P2RI-prefix wells were consistent with a source material comprised of light-end to middle-range hydrocarbons, which are present at the Facility.
- Field observations made during this portion of the investigation yielded information that helped better define groundwater flow and transport conditions at the Facility and within the Town of Sunburst.
 - In some discrete areas, groundwater was not observed in both shallow and deep boreholes, indicating minimal and/or non-presence of groundwater in those areas.
 - Fine-grained alluvial sediments west of the Town of Sunburst and the Facility's tank farm area were typically dry, and groundwater was not observed until the weathered shale was encountered.
 - Groundwater under significant semi-artesian or artesian pressure was observed within the alluvial sediment portion underlying the Town of Sunburst and along the county road south of town. Artesian conditions were observed upon penetrating the top of the weathered shale. Monitoring wells installed at the top of the weathered shale in the eastern portion of town exhibited potentiometric heads that were significantly higher (8-12 feet) than the elevation of the top of weathered shale.

Observations made during drilling and groundwater elevation data collected during the first investigation stage indicated that two distinct groundwater flow systems exist beneath the Facility (overburden and weathered shale) and the adjacent property within the Town of Sunburst. Groundwater levels from shallow-deep monitoring well pairs installed during the first stage indicated a downward gradient exists in the tank farm area and an upward gradient exists within portions of the Town of Sunburst. The degree of connection between the two water-bearing zones was poorly understood.

The data suggested a very complex relationship of contaminant and groundwater flow within the hydrostratigraphic units present at the Facility. As stated in Section 2.1.2, a hydrostratigraphic unit is defined as a body of sediment and/or rock characterized by groundwater flow that can be demonstrated to be distinct in both unstressed (natural) and stressed (pumping) conditions, and is distinguishable from flow in other hydrostratigraphic units. As discussed in the Phase II RI Work Plan, data from the first investigation stage suggested that groundwater within the weathered shale, in some portions of the Facility, is under confined conditions and that the weathered shale may act as the source of water where wells are screened across both the alluvial sediments and the weathered shale. Within the Town of Sunburst, the finer-grained alluvial sediments overlying the weathered shale may function as a confining layer, rather than as a water-bearing zone. Historical data suggested that coarser-grained alluvial sediments function as localized water-bearing zones. Understanding where, and to what degree, the weathered shale influences the coarser glacial sediments is a key to understanding the complicated groundwater system beneath the Town of Sunburst.

Wells with long screen intervals bridging both the alluvial sediments and weathered shale could function as a direct conduit for upwelling and movement of groundwater from the weathered shale into intervals within the overlying shallower sediments. Based upon the understanding and knowledge of the role that the weathered shale zone plays in influencing groundwater presence and movement within the overlying alluvial sediments, CEMC proposed to plug and abandon a number of previously installed monitoring wells within town and at the former refinery, because the screen interval was either submerged or displayed extreme artesian conditions.

As part of the second stage of the groundwater investigation, CEMC plugged and abandoned the following monitoring wells: GW-4, GW-5R, GW-6R, GW-15, GW-16, GW-17, GW-20, GW-21, GW-22, GW-24, GW-25, GW-28, GW-30, LSSI-24, LSSI-25, LSSI-41, LSSI-42, PA-2, PA-5, P2RI-18, and P2RI-25S (Appendix 4-E). Replacement wells with appropriate screened interval were installed in those areas where evaluation and data collection were still necessary. Replacement wells were installed at the following locations: GW-4R, GW-5RR, GW-16R, GW-17R, GW-20RS, GW-20D, GW-25R, GW-30R, PA-5R, P2RI-18SR, and P2RI-18D. Replacement wells were installed at depths and with well screens that did not cross different hydrostratigraphic units.

4.2.2 SECOND STAGE OF PHASE II RI GROUNDWATER INVESTIGATION (SEPTEMBER 2010 – NOVEMBER 2011)

In September 2010, CEMC began the second groundwater investigation stage of the Phase II RI. The objectives were to build upon the information collected during the first stage, further enhance the Facility's CSM, and further delineate the occurrence and migration of LNAPL and impacted groundwater associated with historic refining activities at the former refinery. As such, a monitoring well installation program was designed to target specific geographic areas for evaluation of extent of impacts both laterally and vertically.

To meet those objectives, the following activities were conducted during the second groundwater investigation stage of the Phase II RI.

- Investigations regarding the nature and geographic extent of LNAPL occurrence and chemical forensics – The goal of the investigation was evaluate source LNAPL migration both vertically and laterally throughout the Facility and Town of Sunburst. CEMC utilized existing and newly installed monitoring wells to evaluate the three subsurface zones through which LNAPL may potentially migrate (shallow zone, deep zone where geophysical data indicates flow is likely to occur, and the deep fractured bedrock zone). CEMC also expanded the LNAPL forensic investigation to better understand the chemical nature of petroleum impacts and identify potential source areas (Section 4.10).
- Evaluation of hydraulic conductivity of shallow and deep water-bearing zones and connectivity between water-bearing zones – Geologic, groundwater, and geophysical data from previous investigations, as well as data from the first stage of the Phase II RI, were evaluated to better understand the presence of multiple water-bearing zones and the potential for vertical connectivity within the multiple water-bearing zones. CEMC further expanded this evaluation through the installation of multiple clustered monitoring wells screened in separate vertical zones, and also through the performance of a series of aquifer pumping tests (Section 4.5).

4.3 DEVIATIONS FROM WORK PLAN

Deviations from the Phase II RI Work Plan occurred during various stages of the investigation, including during soil sampling/screening, monitoring well development, and groundwater sampling, as described in the following subsections.

4.3.1 SOIL SCREENING AND SAMPLING

Deviations from the Phase II RI Work Plan occurred during drilling of the shallow, deep, and deep-fracture monitoring well borings. The primary deviations were in relation to field screening and soil sample collection. Deviations related

to soil sample collection occurred in some instances where a soil sample was not submitted to the analytical laboratory for analysis. Table 4.3-1 provides a summary of soil sampling deviations and includes the rationale or explanation for the deviation.

Deviations related to field screening and sample collection were as follows:

- The Phase II RI Work Plan indicated acetate liners would be utilized during the coring process. However, soil core recovery and drilling conditions dictated whether an acetate liner could be used in each 5-foot core run. As drilling proceeded through more competent shale, the acetate liner often melted and failed due to the high temperatures generated by the rotary drilling action. Rather than suffer a lack of core recovery and loss of valuable data, the use of liners was discontinued if competent cores could not be recovered. In each case where liners were not used, excellent rates of core recovery were achieved.
- In some instances, the hardness/competence of the shale encountered did not allow advancement of the continuous core barrel and hollow stem auger. In these cases, the continuous core barrel was removed and drilling resumed using a center bit. Field screening and lithologic descriptions were conducted on drill cuttings.
- Clearance for underground utilities at monitoring well locations within and south of the developed portion of the Town of Sunburst was completed by hydrovac removal of the top 6 to 7 feet of soil. As a result, field screening and lithologic descriptions for the first 6 to 7 feet of soil were not performed at these locations.

4.3.2 MONITORING WELL DEVELOPMENT

The goals of well development are (1) to enhance the hydraulic connection between the water-bearing formation and the newly installed wells, and (2) to remove the clay, silt, and fine sand particles from the sand filter pack and adjacent formation. Each groundwater monitoring well was developed (if adequate groundwater was present) by mechanically surging with a PVC surge block or using a submersible pump or bailer. After surging, groundwater and water introduced during well construction (i.e., hydration water added to the bentonite) was removed. Each well was either pumped or bailed until 10 well casing volumes had been removed, or until the well was dry.

Deviations from the Phase II RI Work Plan that occurred during monitoring well development were primarily due to insufficient volume of groundwater within certain monitoring wells, resulting from the tight nature of the formation in which the wells were completed.

At the time of well development of stage one and stage two monitoring wells, 25 were dry prior to beginning development. During development, 35 wells were bailed/pumped dry; groundwater volumes produced from those

wells ranged from less than one gallon to approximately 23 gallons (for example, GW-ED, a 4-inch diameter well). Portable field equipment was used to measure the conductivity, pH, temperature, turbidity, DO, and salinity of samples of the fluid removed during well development. The development forms in Appendix 4-B include the field parameter readings collected during development of the wells installed as part of the Phase II RI.

4.3.3 GROUNDWATER SAMPLING

Deviations from the Phase II RI Work Plan that occurred during groundwater sampling were primarily due to insufficient volume of groundwater within certain monitoring wells. Two deviations that occurred due to insufficient volume of groundwater and low groundwater production rates were well evacuation/extraction methods, and sample analyses performed.

The Phase II RI Work Plan, and documents referenced therein, states groundwater samples would be collected from the wells by low-flow purging and sampling techniques, using dedicated portable submersible sampling pumps capable of purging groundwater at low flow rates (<250 ml/min). The Phase II RI Work Plan further states dedicated polyethylene tubing would be used for collection of groundwater samples by low-flow purging and sampling techniques. For monitoring wells that did not contain sufficient volume of groundwater, or a recharge rate that allowed for sampling using low-flow purging and sampling techniques, samples were collected using disposable polyethylene bailers. Table 4.3-2 provides a summary of each groundwater sampling event and indicates which sampling method was performed.

The Phase II RI Work Plan also indicated that groundwater samples would be analyzed for the analytes on the Facility's COI list (Table 2.1-2). However, at some monitoring well locations the volume of available groundwater was insufficient to fill the full suite of laboratory bottles. In those cases, the preferred order for filling sample bottles was dictated by the constituents of greatest interest. Generally, the order in which bottles were filled when there was insufficient groundwater was as follows:

- Three 40 ml HCL preserved vials for VOCs by 8260
- Three 40 ml HCL preserved vials for MT-VPH
- One 1-L unpreserved amber bottle for SVOCs
- One 1-L unpreserved amber bottle for SIM analysis (if applicable)
- One 1-L HCL preserved amber bottle for MT-EPH
- One 1-L unpreserved amber bottle for TEL

- One 250 ml HNO₃ preserved plastic bottle for Metals by 6010
- One 250 ml NaOH preserved plastic bottle for Cyanide by 9012A

Dependent on the remaining volume of groundwater, the four remaining one liter amber bottles were filled in the same order as the ambers above (2 unpreserved, 1 preserved, 1 unpreserved).

Table 4.3-2 lists all the monitoring wells associated with the Phase II RI and the laboratory analyses performed on groundwater samples collected from each well during the sampling events. Note that samples for dissolved metals analysis were collected during the third and fourth quarter 2012 groundwater sampling events. These data are included in Appendix 4-I.

4.3.3.1 GROUNDWATER SAMPLING FREQUENCY

The Phase II RI Work Plan stated that groundwater samples would be collected from the newly installed monitoring wells on a quarterly basis for one year after installation and analyzed for the constituents included on the groundwater COI list. The Draft Phase II RI Report summarized groundwater data collection activities through the second quarter of 2012. Data associated with the fourth (and final) groundwater sampling event were not presented in the Draft Phase II RI Report for 17 monitoring wells that were installed during the fourth quarter of 2011 (P2RI-28S, P2RI-29S, P2RI-30S, P2RI-31S, P2RI-32S, P2RI-55S, P2RI-55DF, P2RI-56S, P2RI-56DF, P2RI-57S, P2RI-58S, P2RI-59S, P2RI-60S, P2RI-61S, P2RI-62S, P2RI-63S, and PA-5R).

The fourth quarterly sampling event at the above listed wells was conducted during the third quarter of 2012, and data collected are included herein. Associated field forms for this event are included in Appendix 4-I. Also included in Appendix 4-I are tabulated laboratory analytical results, laboratory analytical reports, and data validation summary reports. Figures 4.6-1 and 4.6-2 depict reported concentrations for those organic or inorganic constituents exceeding the MDEQ groundwater standard or screening level at the Phase II RI wells. Laboratory analytical results from the third quarter 2012 groundwater sampling event are similar to those of the previous three quarterly sampling events and are consistent with the CSM presented in the Draft Phase II RI Report. The data can be summarized as follows:

- There were no reported organic constituent concentration exceedances in the groundwater samples collected from the 13 monitoring wells along the county road and extending east into the lake bed. Of these 13 locations, cobalt was the only reported inorganic constituent that exceeded the MDEQ standard or screening level during the third quarter 2012 groundwater sampling event.

- Groundwater samples from well P2RI-28S were not submitted for inorganic analyses during first three quarterly sampling events due to insufficient water volume. All inorganic constituent concentrations during the last quarterly groundwater sampling event were either below MDLs or MDEQ groundwater standards/RBSLs.
- There were five quarterly groundwater sampling events performed at well P2RI-56DF. Reported benzene concentrations in the groundwater samples collected during the fourth quarter 2011 and fourth quarter 2012 both exceeded the MDEQ groundwater standard; however, the reported benzene concentration decreased from 0.021mg/L to 0.0054 mg/L during the sampling time period.
- There were no reported organic constituent concentrations exceeding MDEQ standards or RBSLs in the groundwater samples collected from well P2RI-60S during the first two quarterly sampling events (fourth quarter 2011 and first quarter 2012). Reported concentrations of benzene (0.018 mg/L) and 1,3-butadiene (0.0024J mg/L) both exceeded their applicable MDEQ standards during the second quarter of 2012. There were no reported organic constituent concentrations exceeding MDEQ standards or RBSLs in the third quarter 2012 groundwater sample submitted from well P2RI-60S.

4.3.3.2 PVC PRIMER

After the second quarter 2011 sampling event, 2-butanone was reported by the laboratory at an elevated concentration in the groundwater sample collected from well P2RI-18SR. Upon further investigation, PVC primer was found to be present within the uppermost portion of casing at this well, and the use of PVC primer during April 2011 well surface completions was verified with the subcontractor. The PVC primer was used to increase the length of the above-ground portion of the PVC well casings. PVC primer was also used at wells P2RI-16D, P2RI-25D, P2RI-27S, and GW-NS, which were completed in April 2011. CEMC notified MDEQ via phone that PVC primer had been mistakenly used at these locations during well completion activities. After notifying MDEQ, CEMC conducted mitigation activities consisting of surging/flushing of the wells in conjunction with scrubbing the affected portion of well casing with a wire brush and/or well development tool (hardened rubber ring), and pumping the well to dryness. Groundwater purged from the wells was containerized and disposed of in accordance with the MDEQ guidelines. Once groundwater had recharged to static level in each well, surging/flushing was repeated. This process was repeated several times throughout the months of June and July 2011. CEMC also performed two follow-up groundwater sampling events during June and July 2011 at wells P2RI-16D, P2RI-18SR, P2RI-25D, P2RI-27S, and GW-NS. For both events, the analytical laboratory analyzed the samples for those VOCs on the Facility's COI list, which includes cyclohexane and 2-butanone. The lab also reported the concentration of any tentatively identified compounds (TICs) in the samples, including acetone and tetrahydrofuran. Acetone, 2-butanone, cyclohexane, and tetrahydrofuran are identified on the Material Safety Data Sheet (MSDS) for purple PVC primer as the primary chemical components. As shown in

Table 4.3-3, the concentration of 2-butanone at well P2RI-18SR had decreased from the June 2011 reported concentration of 100 mg/L to below laboratory detection limits in September 2011.

4.3.4 LONG-TERM PUMPING TEST AT WELL P2RI-9D

The Phase II RI Work Plan originally proposed long-term groundwater pump tests to evaluate hydraulic interactions between shallow and deep water-bearing zones at three locations: P2RI-9D, P2RI-45E, and sonic boring E. Understanding of hydraulic connectivity between water-bearing zones has significantly increased since June 2010 throughout the Facility and Town of Sunburst with the installation of numerous shallow/ deep monitoring well pairs, as well as the August/September 2011 performance of long-term pumping tests at two of the three proposed locations (GW-ES and P2RI-45E, Section 4.5.2). A pump test was not conducted at location P2RI-9D during that time period, as perimeter observations wells along the western side of the BNSF railroad tracks had not yet been installed due to delays in obtaining property access. Data gathered during the long-term pump test conducted at location P2RI-45E provided useful information regarding hydraulic interactions in that area between shallow and deep water-bearing zones. However, pump testing at GW-ES yielded very little information about the connectivity between hydraulic units there due to the low specific capacity of the pumping well (i.e., the well was not capable of maintaining a pumping rate sufficient to observe vertical communication between water-bearing units or observe effects in nearby observations wells).

Based on the results of the long-term pump test conducted at GW-ES, CEMC performed a short-term pump test at monitoring well P2RI-9D to determine its viability for a long-term test. In February 2012, approximately 8.5 gallons of groundwater was pumped from the well in 12 minutes, at a rate of approximately 0.75 gallons per minute. After 12 minutes time, the well was dry. No change in groundwater level in the nearby shallow well counterpart (P2RI-9S) was observed during pumping. Based on these results, MDEQ agreed in a March 23, 2012 letter that a long-term pump test at P2RI-9D was not feasible for achieving the stated goal of the activity (i.e., determine hydraulic interactions, if any, between shallow and deep water-bearing zones in this portion of the Facility).

4.3.5 HYDROCARBON RECOVERY TEST (TANK BERMS 10 AND 18)

The Phase II RI Work Plan originally proposed hydrocarbon recovery tests for Tank Berms 10 and 18, based upon observations made during installation and screening of soil borings in those tank berms during late 2009. CEMC proposed installation of recovery wells (4-inch diameter) to assess the feasibility of LNAPL recovery within the impacted berms. During the period of September through November 2010, CEMC installed two 4-inch wells within Tank Berm 10 (P2RI-42S and TB10-RW) and one 2-inch well within Tank Berm 18 (P2RI-40S). Hydrocarbon recovery testing was not conducted at the wells in either tank berm due to (1) minimal thickness of LNAPL in the two

wells located within Tank Berm 10 (maximum thickness was 0.27 feet in February 2011 at TB10-RW) and (2) no LNAPL being present in the well within Tank Berm 18. Recovery well TB10-RW is currently part of the routine monthly LNAPL monitoring and recovery network. Approximately 1.27 gallons of LNAPL have been recovered from well TB10-RW since recovery efforts began in February 2011.

Soil borings were installed in Tank Berm 18 during November 2009 as part of the subsurface soil investigation/tank berms portion of the Phase II RI. At one soil boring (TB18-E05-DP01), a highly weathered crude oil or crude oil residue was encountered at approximately 4 ft-bgs (likely a disposal pit where tank bottom material was placed during tank cleaning activities), and a 1-inch diameter temporary groundwater monitoring well was installed in the soil boring. As noted in Section 3.3 of the Phase II RI Work Plan, fluid level monitoring at the temporary well within Tank Berm 18 confirmed the presence of LNAPL. In September 2010, CEMC attempted to install a 4-inch diameter recovery well next to the 1-inch temporary well. However, the recovery well could not be constructed due to subsurface conditions. Due to the consistency of the crude oil residue (thick, viscous, and flowing), the borehole would not remain open long enough to allow placement of sand filter pack or bentonite seal in the annular space around the PVC screen and riser. The previously installed temporary groundwater monitoring well had been placed by pushing slotted PVC down into the direct push soil boring and through the crude oil residue; no filter pack or annular seal was placed around the PVC piping.

After the unsuccessful attempt at installing the 4-inch recovery well, a 2-inch diameter groundwater monitoring well (P2RI-40S) was installed in a proximal location during November 2010 for purpose of assessing groundwater quality in the vicinity of the crude oil/crude oil residue. Depth to groundwater is measured at P2RI-40S on a quarterly basis during routine quarterly site-wide gauging events, and no LNAPL has ever been observed (Table 4.1-2). Furthermore, groundwater sample analytical results indicate little to no measurable concentration of dissolved phase hydrocarbon present. Data collected from Tank Berm18 indicates that the highly weathered crude oil or crude oil residue present in the subsurface is of limited quantity (estimated to be approximately 40 cubic yards volume, based upon additional soil borings installed in close proximity to the original soil boring) and is contained within an isolated area of the tank berm.

4.4 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendices 4-G and 4-H.

4.4.1 GROUNDWATER

A total of 628 samples consisting of 444 environmental samples, 43 blind duplicates, 26 equipment blanks, 23 field blanks, and 92 trip blanks, were collected between January 2010 and May 2012. This collection effort resulted in approximately 49,051 sample results including: 37,083 environmental sample results, 3,962 field duplicate sample results, 2,274 equipment blank sample results, 2,060 field blank sample results, and 3,672 trip blank sample results. The data were reported in 63 lab data packages that were reviewed and validated. The laboratory reports are included in Appendix 4-F, and the individual data validation reports are included in Appendix 4-G.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the data validation review, laboratory J flags were preserved in the data. A total of 3,005 data points were qualified as J by the laboratory. Out of these laboratory J flags, 2,093 were preserved during the Tier III data validations.

The following table summarizes the distribution of the applied data qualification flags:

Flag	Total
J	3,876
UJ	2,925
JB	538
R	292
TOTAL	7,631

Data qualifiers applied to this data set are discussed in detail in Appendix 2-B and in the individual data validation reports in Appendix 4-G. Data qualification summaries are also included in each data validation report as Attachment B.

Of the 41,045 environmental and field duplicate sample results reported and validated between January 2010 and May 2012, 278 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the groundwater sampling activities is 99.32%, which is greater than the required 90%.

4.4.2 SOIL

A total of 192 samples consisting of 120 environmental samples, 14 blind duplicates, 13 equipment blanks, 1 field blank, and 44 trip blanks were collected between December 2009 and November 2011. This collection effort resulted in approximately 15,636 sample results including: 11,218 environmental sample results, 1,316 field duplicate

sample results, 1,209 equipment blank sample results, 93 field blank sample results, and 1,800 trip blank sample results. The sample results were reported in 68 lab data packages that were reviewed and validated. The laboratory reports are included in Appendix 4-F, and the individual data validation reports are included in Appendix 4-G.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the data validation review, laboratory J flags were preserved in the data. A total of 1,076 data points were qualified as J by the laboratory. Out of these laboratory J flags, 746 were preserved during the Tier III data validations.

The following table summarizes the distribution of applied data qualification flags:

Flag	Total
J	1,887
UJ	530
JB	127
R	196
TOTAL	2,740

Data qualifiers applied to this data set are discussed in detail in Appendix 2-B and in the individual data validation reports in Appendix 4-G. Data qualification summaries are also included in each data validation report as Attachment B.

Of the 12,534 environmental and field duplicate sample results reported and validated between December 2009 and November 2011, 196 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the monitoring well soil sampling activities is 98.44%, which is greater than the required 90%.

4.5 SITE CHARACTERIZATION RESULTS

The following subsections provide a summary of the groundwater investigation portion of the Phase II RI, with an emphasis on discussion of the geologic and hydrogeologic conditions present at the Facility. During the course of the investigation, and with the assimilation of data collected from previous groundwater investigation activities, it was reinforced that the gathering of depth specific, detailed information at each well boring was key to gaining better understanding and conceptualizing the groundwater and contaminant migration regime in that area of the Facility. Information gathered at each boring included identifying subsurface lithology, evidence of historical or current

presence of fluid migration pathways (e.g., zones of coarser-grained, more permeable materials, fracture zones, presence of moisture in bed parting planes), identifying the depth of transition from overlying sediment and weathered shale, and degree of weathering of the shale bedrock. All of those separate pieces of information are necessary to understanding how refinery-related contamination has migrated and come to be present currently. Facility boundaries based on groundwater investigation results are depicted in the updated CSM, presented in Chapter 7.0 of this Report.

4.5.1 SITE GEOLOGY

The geology of the Sunburst area is described generally in Section 1.3, and discussed in greater detail in the updated CSM presented in Chapter 7.0. This section presents a limited overview of the results of activities conducted as part of the Phase II RI, which have contributed to the current conceptual model of site geology.

Phase II RI activities associated with characterizing site geology included:

- Installation of 139 wells (monitoring and recovery)
- Lithologic review of previously installed boreholes
- Soil borings in the tank farm area and along the railroad corridor
- Review of local geologic maps and topographic elevations
- Interpolating elevations of geologic contacts from borehole logs in three dimensions to create surfaces for each contact and bounding volumes for each geologic unit

Evaluation of data existing prior to the initiation of the Phase II RI identified three geologic units at the Facility and within the Town of Sunburst:

- Surficial glacial sediments
- Shallow weathered/highly fractured shale
- Deeper, more competent shale

Results of the Phase II RI have led to further subdivision of surficial glacial sediments into two separate units: glacial drift and alluvial sediments. Generally, the glacial drift forms the surficial sediments in the western portion of the Facility, while alluvial sediments comprise the surficial sediments in the eastern portion of the Facility. The lateral contact between the two units is gradational, and is located approximately as shown on Figure 4.5-1. The thickness of the glacial drift varies from less than 10 feet to greater than 50 feet. An isopach map of the glacial drift is shown on Figure 4.5-2. Near the contact with glacial drift, the thickness of the alluvial sediments is approximately 10-20 feet,

and thickening toward the east. An isopach map of the alluvial sediments is shown on Figure 4.5-3. The glacial drift and alluvial sediments lie unconformably atop the weathered surface of the Kevin Member of the Marias River Shale. Over most of the central and western portions of the Facility, the elevation of weathered shale surface undulates gently while generally decreasing to the north and east (Figure 4.5-4). The thickness of the weathered zone is variable, ranging from less than 10 feet to more than 50 feet (Figure 4.5-5). The degree of weathering gradually decreases with depth, with a transition to less weathered, more competent shale. A structure contour map of the top of competent shale is shown on Figure 4.5-6.

Figure 4.5-7 provides several views of a 3-dimensional geologic model which incorporates all of the above units. Image B on Figure 4.5-7 shows an east-west cross sectional view through the center of the Facility, and Image C on Figure 4.5-7 shows a north-south cross sectional view along the approximate contact between glacial drift and alluvial sediments.

4.5.2 HYDROGEOLOGIC CONDITIONS

The hydrogeology of the Sunburst area is extremely complex, complicated by the presence of multiple hydrostratigraphic units with variable degrees of heterogeneity within those units, and irregular flow pathways. Several datasets have been used to characterize the occurrence of groundwater and flow direction(s). This section describes the hydrostratigraphic units present at the Facility and pump testing activities conducted as part of the Phase II RI. Section 7.1.2 provides a more complete discussion on the hydrogeology as it pertains to the Facility's CSM.

4.5.2.1 HYDROSTRATIGRAPHIC UNITS

As previously discussed, a hydrostratigraphic unit is defined as a body of sediment and/or rock characterized by groundwater flow that can be demonstrated to be distinct in both unstressed (natural) and stressed (pumping) conditions, and is distinguishable from flow in other hydrostratigraphic units. The hydrostratigraphic units present at the Facility are roughly analogous to the geologic units discussed in Section 4.5.1, with the exception that the glacial drift and weathered shale are considered to function as a single hydrostratigraphic unit.

- **Alluvial Sediments** – also referred to as “clay” or “clay overburden”. The alluvial sediments unit is present along the eastern boundary of the former refinery property and extends northward into the central portion of the Town of Sunburst and eastward into an ephemeral lakebed (Figure 4.5-1). The unit thickens towards the east. The alluvial sediments are primarily composed of dense clay. Thin lenses and stringers of sand are dispersed throughout the unit, and are the primary conduits for fluid movement within this unit. The coarser grained portions of the alluvial sediments function as a significant water-bearing unit, particularly within the Town of Sunburst and along the eastern margins of the Facility. The fine-grained layers exert a confining pressure on the saturated portions of the

alluvial sediments at depth, and on the weathered shale unit below. Generally, the fine grained alluvial sediments function as a hydrologic barrier between the saturated portions of the alluvial sediments and the saturated portions of the weathered shale. However, the fine grained layers are not uniformly distributed, and there may be vertical communication in various locations. On a broad scale, the fine grained alluvial sediments can be considered a leaky confining layer. Groundwater flow within the sandy intervals is discontinuous and not well understood.

- ***Weathered Shale*** – The weathered shale hydrostratigraphic unit is comprised of two distinct lithologic units: shallow weathered/highly fractured shale and overlying glacial drift sediments. The glacial drift is present in the central and western portions of the Facility, while in the eastern portion of the Facility the surficial sediments have significantly different hydraulic properties and function as a different hydrostratigraphic unit (alluvial sediments). The weathered shale is present over the entire footprint of the Facility. In the western area where both glacial drift and weathered shale are present, groundwater within this hydrostratigraphic unit generally occurs mostly or entirely within the weathered shale. The volume of groundwater within the glacial drift is small because the majority of that lithologic unit is above the potentiometric surface. In the eastern portion of the Facility, groundwater within the weathered shale is under confined and artesian conditions in most locations. The artesian conditions are due to fine grained layers in the overlying alluvial sediments and a significant hydraulic head gradient from the saturated portions of the weathered shale at higher elevations to the west. The nature and degree of weathering within the shale is highly variable. Boring log data suggest that two weathering zones exist within the weathered shale unit. However, the degree of weathering is difficult to define and map across the site. In some locations the two zones have a very distinct boundary and in others, the weathering boundary is variable and gradational, and difficult to characterize. Due to the variability in weathering intensity and character, flow paths within the weathered shale are not completely understood and may deviate from the directions expected based on groundwater gradient.
- ***Competent Shale*** – The lower portions of the weathered shale zone are characterized by a gradual transition to unweathered competent shale. The competent shale is thinly and discretely fractured. Some fractures are water-bearing or contain minor moisture. Other fractures are dry but have mineralization or alteration products that indicate past fluid movement. Still other fractures are completely dry and show no sign of past moisture. Some monitoring wells installed in this unit have accumulated very large static water columns over time, but recharge from the deep fracture zones tends to be very slow if the water column is disturbed.

4.5.2.2 PUMP TESTING

During the drilling and installation of new monitoring wells in and around the Town of Sunburst, large differences in static water levels were observed with respect to the “wet” zones in which the wells were screened, based upon soil sampling data. For example, in some newly installed wells the screened interval was 18-25 ft-bgs and static water

levels were only a few feet below the measuring point (top of well casing). The new monitoring well data complicated the current understanding of the hydrogeology. As a result, pump testing programs were conducted at two locations (P2RI-45E and GW-ES) to gain a better understanding of the degree of connectivity between differing groundwater regimes (Figure 4.5-8).

The objectives of the pump tests were as follows:

- Evaluate the hydraulic interaction between the discrete water-bearing regimes
- Assess the potential for hydrocarbon recovery
- Determine the pump test radius of influence on groundwater equilibrium
- Quantitatively estimate bulk hydraulic properties

Each pump test consisted of a stepped discharge test, post-step recovery, and a constant rate discharge test. The number of step tests was determined in the field based on the observed groundwater recharge rate. Results from the step test were used to determine a sustainable flow rate for the constant rate discharge test. Note that the maximum sustainable flow rate, determined by the step test, had a significant effect on the ability to reach the proposed objectives.

A Virtual HERMIT[®] Aquifer Testing Kit, in conjunction with Level TROLL[®] 700 pressure transducers, were used to record fluctuations in the depth to groundwater (ft), pressure (psi), and groundwater temperature (°C). Each well within the pump test area, identified on Figure 4.5-8, was hardwired to the Virtual HERMIT[®] control box allowing real time data collection and plotting. Nearby monitoring wells, within the maximum suspected radius of influence, were equipped with standalone pressure transducers requiring manual download. The data manually downloaded was then synchronized with the Virtual HERMIT[®] software allowing direct data comparison between all monitored locations. A list of monitored wells and associated equipment, for each pump test location, is described below.

- P2RI-45E – Pump test location, Level TROLL[®] 700 hardwired to Virtual HERMIT[®] control box
 - P2RI-45D – Level TROLL[®] 700 hardwired to Virtual HERMIT[®] control box
 - P2RI-45S – Level TROLL[®] 700 hardwired to Virtual HERMIT[®] control box
 - P2RI-45T – Level TROLL[®] 700 hardwired to Virtual HERMIT[®] control box
 - LSSI-37 – Equipped with standalone Level TROLL[®] 700 pressure transducer
 - P2RI-5S – Equipped with standalone Level TROLL[®] 700 pressure transducer

- P2RI-5 – Equipped with standalone Level TROLL[®] 700 pressure transducer
- GW-C-47S – Equipped with standalone Level TROLL[®] 700 pressure transducer
- GW-MDF – Equipped with standalone Level TROLL[®] 700 pressure transducer
- GW-C-29 – Equipped with standalone Level TROLL[®] 700 pressure transducer
- GW-ES – Pump test location, hardwired to Virtual HERMIT[®] control box
 - GW-ED – Level TROLL[®] 700 hardwired to Virtual HERMIT[®] control box
 - Boring E – Level TROLL[®] 700 hardwired to Virtual HERMIT[®] control box
 - GW-13 – Equipped with standalone Level TROLL[®] 700 pressure transducer
 - GW-12 – Equipped with standalone Level TROLL[®] 700 pressure transducer
 - GW-5RR – Equipped with standalone Level TROLL[®] 700 pressure transducer
 - P2RI-16D – Equipped with standalone Level TROLL[®] 700 pressure transducer
 - P2RI-16S – Equipped with standalone Level TROLL[®] 700 pressure transducer

Both pump test areas consist of a series of discretely screened monitoring wells comprising a monitoring well network. Monitoring well specifics (static groundwater elevation, elevation top and bottom of screen, elevation of weathered and competent shale, etc.) pertaining to each network can be seen on Figures 4.5-9 and 4.5-11 for locations P2RI-45E and GW-ES, respectively. Pump tests were subsequent isolated assessments, not performed simultaneously.

4.5.2.2.1 MONITORING WELL P2RI-45E PUMP TEST

One area with a complex groundwater regime is the northwest portion of the former tank farm associated with the P2RI-45 well cluster. In this area, groundwater is very shallow but deeper zones of groundwater are also present. In addition, periodic groundwater seeps have been observed in Surface Drainage 01, a few hundred feet north of the P2RI-45 area. A constant rate pump test was proposed and conducted in attempt to better understand the groundwater flow conditions.

As depicted on Figure 4.5-9, there are four wells installed at the P2RI-45 location; P2RI-45E, P2RI-45S, P2RI-45D, and P2RI-45T. Well P2RI-45E is a 4-inch well (pumping well) and is screened in the weathered shale unit. P2RI-45T is a temporary monitoring well and is screened over the same interval. P2RI-45S is screened both in the glacial drift and the weathered shale, while P2RI-45D is screened in the competent shale. These were the principal wells where expected influence would be observed. Water levels in six other wells were also part of the P2RI-45 pump test;

P2RI-5, P2RI-5S, LSSI-37, GW-C-29, GW-C-47S, and GW-MDF. All wells were equipped with pressure transducers to measure any groundwater fluctuations during pumping.

A step drawdown test was conducted on August 24, 2011 to estimate a pumping rate for the 3-day constant rate test (Figure 4.5-10). The step test results indicated that a rate of 1.5 to 1.75 gpm would be sustainable during the constant rate testing. The pump was shut down after the step test and water levels were allowed to recover to +95% of the pre-test water level.

The constant rate test began on the afternoon of August 25, 2011 and pumping continued until the morning of August 29, 2011 at a constant rate of 1.65 gpm. Total pumping time was 90 hours. Maximum drawdown within the pumping well (P2RI-45E) was 5.3 feet. A maximum drawdown of 2.5 feet was observed in well P2RI-45T, approximately 25 feet to east of the pumping well. Drawdown was also observed 300 feet to the west in P2RI-5 (0.7 feet), which was screened in a similar hydrogeologic interval.

LNAPL was observed in the pumping well after approximately two feet of drawdown was achieved. LNAPL was removed from the well each morning using a peristaltic pump, and maximum thickness of approximately three feet was observed. During the course of the pump test (90 hours), a total of 8,910 gallons of groundwater and 7.95 gallons of LNAPL was extracted from the well. On August 31, 2011 (two days after completion of the pump test and after groundwater level had returned to +95% pre-test elevation), 0.08 feet of LNAPL was measured in the well.

Observation wells P2RI-45D (located 7 feet from P2RI-45E, but screened in competent shale) and LSSI-37 (350 feet from P2RI-45E) showed an unexpected upward trend in measured head. Figure 4.5-10 depicts drawdown versus time during the testing and recovery period. This upward trend suggests that the weathered shale hydrostratigraphic unit behaves as a leaky semi-confining unit overlying the competent shale. As the downward force of the leaky semi-confining layer was decreased by removal of groundwater, the underlying hydraulic head rose within the competent shale hydrostratigraphic unit.

Drawdown data were evaluated using the AQTESOLV software and evaluated at P2RI-45T and P2RI-45S using the Neumann method for unconfined solutions. An estimated transmissivity of $38.8 \text{ ft}^2/\text{day}$ was calculated by this method. Using a saturated thickness of 11 feet, the horizontal hydraulic conductivity was estimated to be $3.5 \text{ ft}/\text{day}$.

As mentioned above, approximately 0.08 feet of LNAPL was measured in well P2RI-45E two days after completion of the pump test. Well P2RI-45E was subsequently included in the monthly LNAPL monitoring and recovery program

and, with the exception of September 2011, no measurable thickness of LNAPL was observed there until September 2012, after completion of a June 2012 nitrate application pilot test.

On June 13, 2012, approximately 13,800 gallons of potable water and 250 pounds of nitrate fertilizer was applied to the ground surface within a 50-foot by 50-foot bermed area surrounding well P2RI-45E. On September 9, 2012, approximately three months after applying the water to the ground surface, a measurable thickness (0.89 foot) of LNAPL was measured at well P2RI-45E. Groundwater level data from well P2RI-45E and surrounding wells did not indicate significant amounts of the applied water ever reached the local shallow groundwater. However, the presence of LNAPL is likely attributed to mobilization and/or improved contact of water with source material (hydrocarbon impacted soils) after the application of water to the ground surface at the P2RI-45E study area. Water passing through impacted soils in the vadose zone would dissolve and mobilize the hydrocarbon, subsequently transporting it to the groundwater.

After performing two separate tests at the P2RI-45E location, one with groundwater removal/extraction and the other with water addition, it appears that residual LNAPL in the subsurface near P2RI-45E is relatively non-mobile under static conditions. Once these static conditions change, either by drawdown or water addition, LNAPL may be mobilized. LNAPL recovery in this area may possibly be enhanced by creating a disturbance to the static conditions within the shallow subsurface. Additional investigations regarding LNAPL recovery in the P2RI-45E area will be evaluated during the forthcoming feasibility study for the Facility.

4.5.2.2.2 MONITORING WELL GW-ES PUMP TEST

Another area where groundwater flow regimes and the presence/absence of LNAPL is complex is near monitoring well GW-ES, and a second constant rate pumping test was conducted there to better understand groundwater flow in this area. GW-ES was selected as the pumping well for this test. Seven wells were monitored for water level changes during this test: GW-12, GW-13, GW-5RR, P2RI-16S, P2RI-16D, GW-ED, and Boring E.

A step drawdown test was conducted on August 29, 2011 to estimate a pumping rate for the 3-day constant rate test. The step test results indicated that a rate of 0.3 to 0.5 liters per minute would be sustainable during the constant rate testing. The pump was shut down after the step test and water levels were allowed to recover to +95% of the pre-test water level.

The constant rate test was started the morning of August 30, 2012 and continued until the morning of September 1, 2012 (Figure 4.5-12). Total pumping time was 45 hours. Well GW-ES was pumped at a rate of 0.48 liters per minute

and when drawdown in the pumping well reached the top of the pump intake, the test was halted. A maximum drawdown of only 0.52 feet was observed in nearby Boring E after 45 hours of testing. The minor amount of drawdown observed was complicated by two distinct weather fronts that moved through the area during the test. The weather fronts, at times, induced a barometric overprint on much of the observation data that complicated interpretation to a degree where confidence in the data is low. Minor drawdown was observed in monitoring GW-5RR, and significant influence was observed by the changes in barometric pressure. As a result, no clear conclusions about groundwater communication between wells and depth intervals can be drawn from the pump test at GW-ES. However, the test does confirm that significant groundwater extraction cannot be sustained in that area of the Facility, and what groundwater extraction can be done has very little affect on any significant surrounding areas.

4.5.2.2.3 FLUID LEVEL COMMUNICATION TESTS

To identify areas of potential flow between groundwater in the alluvial sediments and the weathered shale on the east side of the Facility, fluid level communication tests were conducted at selected well pairs. The well pairs of interest have a deep well screened in the weathered shale and a shallow well screened in the alluvial sediments. Most often, these tests were conducted concurrently with groundwater sampling at one of the wells (i.e., the water level in one well was monitored while purging and collection of a sample from the other well was conducted). At two locations (P2RI-9D/9S and P2RI-26D/26S), short-term fluid level communication tests with a higher flow rate were conducted. The data from these tests are presented in Table 4.5-1. In general, most of the tests indicated no measurable effects in the observation well as a result of groundwater removal from the test well. A slight decrease in water level was observed in P2RI-25S when P2RI-25D was pumped. A similar slight decrease was observed in P2RI-19S when P2RI-19D was pumped. Although small decreases in water level were observed, the tests were short in duration and the flow rate from the extraction well at each test was less than 200 ml/min. The intent of these analyses was not to conclusively prove connectivity or disconnectedness between hydrostratigraphic units at certain locations, but rather provide an additional line evidence to evaluate hydrogeologic connectivity and flow paths. Although the test results cannot be considered conclusive due to their short duration, the current understanding of hydrogeology in the subject test areas do not represent a data gap in the CSM. Section 7.1.3 provides a more detailed discussion on groundwater flow regime connectivity.

4.5.3 GEOGRAPHICAL DIVISIONS OF FACILITY

To provide structure, consistency, and organization to the groundwater analytical results section, the Facility has been divided into five well network management areas (Figure 4.5-13). A tabulated list of locations included within each area's monitoring well network is included in Table 4.5-2. The five well network management areas were determined by assessing geographic distribution of monitoring wells at the Facility, as well as defining each area's unique geologic

and hydraulic properties. The five well network management areas are as follows: Northeast Area, Southeast Area, Southwest Area, Central Area, and Northwest Area. As shown on Figure 4.5-13, each well network management area is bounded by a series of line segments (line segments 1 through 7), which serve to best describe the rationale for determination of the five well network management areas. Each bounding line segment and the areas it borders are described as follows:

- **Line Segment 1** – Separates **Northwest Area** monitoring wells to the west from the **Northeast Area** wells to the east. This line approximates the contact between glacial drift overburden sediments and alluvial sediments. Immediately west of this line shallow groundwater is typically not present, while east of this line shallow monitoring wells produce relatively large amounts of groundwater.
- **Line Segment 2** – Separates **Central Area** monitoring wells to the southwest from **Northeast** wells to the northeast. This line approximates the contact between glacial drift overburden sediments and alluvial sediments. However, because highly impacted groundwater and/or LNAPL is present along this contact line (in the vicinity of monitoring wells GW-31, GW-11, GW-ES, GW-14 and other wells), this geographic boundary was drawn conservatively southwest of the actual contact to keep those more highly impacted wells together in one group (the Northeast Area group).
- **Line Segment 3** – Separates **Southeast Area** monitoring wells to the south from **Northeast Area** wells to the north. This line was drawn for two reasons:
 1. Based on prevailing hydraulic gradient and known source areas (i.e., pipeline release and the former process area), it appears hydrocarbon impacts in the areas north and south of this line have different sources (forensic analysis of hydrocarbon and groundwater samples have shown different types of hydrocarbon impacts in each area (typically a mix of straight run gas and middle distillates with minor amounts of crude oil to the north, and usually exclusively crude oil to the south)).
 2. Hydrogeologic conditions to the north are generally tight saturated clays in overburden sediments and weathered shale aquifer under extreme confined and artesian conditions below; while to the south the hydrogeology is much more variable and less well known. Locally, clays may be present and the weathered shale may be artesian, but there are also locally dry areas and areas absent of clay.
- **Line Segment 4** – Separates **Southeast Area** monitoring wells to the east from **Central Area** wells to the west. Approximates the contact between glacial drift and alluvial sediments. Drawn as a straight line for simplicity.
- **Line Segment 5** – Separates **Southeast Area** monitoring wells to the east from **Southwest Area** wells to the west. Approximates the contact between glacial drift and alluvial sediments. Drawn as a straight line for simplicity.

- **Line Segment 6** – Separates **Southeast Area** monitoring wells to the south from **Central Area** wells to the north. The western segment of this line (W-E trending) divides generally impacted wells to the north from clean/dry wells to the south. The eastern line segment (NW-SE trending) separates generally dry wells to the south from wells to north where groundwater is present (but not necessarily impacted by hydrocarbon).
- **Line Segment 7** – Separates **Northwest Area** monitoring wells to the north from **Central Area** wells to the south. Potentiometric surface mapping in the weathered shale (Figure 7.1-4) indicates that there is a groundwater divide in this area. The line was drawn on the approximate location of the groundwater divide.

4.6 GROUNDWATER ANALYTICAL RESULTS

Groundwater samples were collected and submitted for laboratory analysis of the parameters on the Facility's COI list (Table 2.1-2), as discussed in Section 4.3.3. Groundwater samples were collected for a period of four consecutive quarters from P2RI-prefix wells and non-routine GW-prefix wells that had sufficient water. Table 4.3-2 provides a summary of the Phase II RI groundwater monitoring since its beginning in January 2010, and includes a summary of which laboratory analyses were performed.

Data resulting from the Phase II RI groundwater sampling events as well as supporting documentation are provided in the following:

- Tables 4.6-1 through 4.6-4 – Groundwater Sample Analytical Data Tables. Provides tabulated data for inorganics and organics (VOCs, SVOCs, and EPH-VPH).
- Appendix 4-F – Groundwater Sample Analytical Laboratory Reports.
- Appendix 4-G – Groundwater Sample Data Validation Reports.
- Appendix 4-I – Contains tabulated laboratory analytical data for wells sampled after the submittal of the Draft Phase II RI Report (third and fourth quarter 2012). Includes associated groundwater sample analytical laboratory reports as well as data validation reports.
- Figures 4.6-1 and 4.6-2 – Provides site-wide Phase II RI monitoring well network and includes the analyte concentrations exceeding the MDEQ groundwater standards, or applicable RBSL, for inorganic and organic constituents.

Laboratory analytical results from the Phase II RI groundwater monitoring events were compared to standards established by MDEQ. The process for establishing screening standards is discussed in the MDEQ FAQs section of the

website <http://deq.mt.gov/StateSuperfund/FrequentlyAskedQuestions.mcp>x, and involves a hierarchy of sources as follows:

- Montana Numeric Water Quality Standards Circular-7 (DEQ-7, MDEQ 2012c) or MCLs
- Montana Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases (RBCA, MDEQ 2009a)
- The most recent version of the tapwater Regional Screening Levels (RSLs) for Chemical Contaminants at Superfund Sites (<http://www.epa.gov/region9/superfund/prg/>)

For purpose of the below constituent result summaries, the applicable regulatory limit is referred to as the “MDEQ standard or screening level”.

The following subsections include a discussion of Phase II RI groundwater sampling analytical results for the three primary hydrostratigraphic units at the Facility (alluvial sediments, weathered shale, competent shale). Each hydrostratigraphic unit is further subdivided into the five well network management areas as discussed in Section 4.5.3. Groundwater sampling results are discussed in terms of a statistical evaluation conducted on laboratory analytical results for total inorganic and organic (VOC, SVOC, and VPH-EPH) constituents (Tables 4.6-5 through 4.6-9).

As discussed in Section 2.1.2, total inorganic analyses were discontinued during the third and fourth quarter of 2012. Beginning with the third quarter 2012 sampling event, all groundwater samples were field filtered using a 0.45 micron filter attachment and submitted for dissolved inorganic analyses. Laboratory analytical data associated with these events are presented in Appendix 4-I. Note, the DEQ-7 standard for metals in groundwater is based on dissolved metals and not total metals. Samples required for dissolved metals analysis are field filtered, in order to remove entrained sediment and other inorganic materials. However, MDEQ standards for groundwater are the same for total and dissolved inorganics.

4.6.1 ALLUVIAL SEDIMENTS RESULTS

The following subsections (one subsection for each well network management area) summarize laboratory analytical results for groundwater samples collected from monitoring wells screened in the alluvial sediments unit at the Facility. Note that the glacial drift overburden sediments are included in the weathered shale hydrostratigraphic unit; therefore, not all well network management areas contain monitoring wells screened into the alluvial sediments hydrostratigraphic unit. In these instances, “Does not contain alluvial sediments” is stated in that well network management area’s subsection. Groundwater sample results from wells screened in the glacial drift sediments are discussed in the weathered shale subsection.

Tables 4.6-5 through 4.6-9 provide a statistical summary of groundwater analytical results for each well network management area. Tables 4.6-5 through 4.6-9 are further divided into four separate tables (denoted A through D), which provide a statistical summary for inorganic and organic (VOCs, SVOCs, and VPH-EPH) constituents. For example, Table 4.6-5A provides the statistical summary for *inorganic* constituent results from groundwater samples collected from the Northeast Area wells; Table 4.6-5B provides the statistical summary for *VOC* constituent results from groundwater samples collected from the Northeast Area wells. Each summary is subdivided into the three hydrostratigraphic units (alluvial sediments, weathered shale, competent shale).

4.6.1.1 INORGANIC CONSTITUENTS

Of the metals on the Facility's COI list, lead is the constituent of primary concern. As such, the following provides a discussion of Total Lead results from groundwater samples collected from the alluvial sediment monitoring wells. Note, however, the DEQ-7 standard for metals in groundwater is based on dissolved metals and not total metals. Analytical statistical summary tables for inorganic constituents are provided in Tables 4.6-5A through 4.6-9A.

4.6.1.1.1 NORTHEAST AREA

Total Lead concentrations exceeded the MDEQ standard in 5 groundwater samples from 3 monitoring wells. The highest reported concentration was 0.108 mg/L from well GW-NS.

4.6.1.1.2 SOUTHEAST AREA

Total Lead concentrations exceeded the MDEQ standard in 16 groundwater samples from 15 monitoring wells. The highest reported concentration was 0.0455 mg/L from well P2RI-33S.

4.6.1.1.3 SOUTHWEST AREA

The Southwest well network management area does not contain alluvial sediments.

4.6.1.1.4 CENTRAL AREA

The Central well network management area does not contain alluvial sediments.

4.6.1.1.5 NORTHWEST AREA

The Northwest well network management area does not contain alluvial sediments.

4.6.1.2 ORGANIC CONSTITUENTS

Analytical statistical summary tables for organic constituents are provided in Tables 4.6-5(B, C, D) through 4.6-9(B, C, D).

4.6.1.2.1 NORTHEAST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analysis by all of the methods.

VOCs – Of the 28 VOCs analyzed, **2** exceeded MDEQ standards or screening levels.

- Benzene – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.0095 mg/L from well P2RI-26S.
- 2-Butanone – 1 exceedance from 1 monitoring well. The highest reported concentration was 100 mg/L from well P2RI-18SR. Note, this concentration is attributed to the application of PVC primer to the well casing during well completion activities (see Section 4.3.3.2 for discussion).

SVOCs – Of the 37 SVOCs analyzed, **0** exceeded MDEQ standards or screening levels.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, **2** exceeded MDEQ standards or screening levels.

- C5-C8 Aliphatic – 2 exceedances from 2 monitoring wells. The highest reported concentration was 28.8 mg/L from well P2RI-18SR.
- TPH – 1 exceedance from 1 monitoring well. The highest reported concentration was 28.8 mg/L from well P2RI-18SR.

4.6.1.2.2 SOUTHEAST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **2** exceeded MDEQ standards or screening levels.

- Benzene – 5 exceedances from 2 monitoring wells. The highest reported concentration was 0.17 mg/L from well P2RI-53S.
- 1,3-Butadiene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.0024 mg/L from well P2RI-60S.

SVOCs – Of the 37 SVOCs analyzed, **2** exceeded MDEQ standards or screening levels.

- Benzo(a)anthracene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.00013 mg/L from well P2RI-32S.
- Bis(2-Ethylhexyl)phthalate – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.032 mg/L from well P2RI-9S.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, **4** exceeded MDEQ standards or screening levels.

- C5-C8 Aliphatic – 4 exceedances from 1 monitoring well. The highest reported concentration was 1.88 mg/L from well P2RI-53S.
- C9-C10 Aromatic – 3 exceedances from 1 monitoring well. The highest reported concentration was 2.42 mg/L from well P2RI-53S.
- C9-C12 Aliphatic – 1 exceedance from 1 monitoring well. The highest reported concentration was 1.11 mg/L from well P2RI-53S.
- TPH – 4 exceedances from 1 monitoring well. The highest reported concentration was 4.54 mg/L from well P2RI-53S.

4.6.1.2.3 SOUTHWEST AREA

The Southwest well network management area does not contain alluvial sediments.

4.6.1.2.4 CENTRAL AREA

The Central well network management area does not contain alluvial sediments.

4.6.1.2.5 NORTHWEST AREA

The Northwest well network management area does not contain alluvial sediments.

4.6.2 WEATHERED SHALE RESULTS

The following subsections summarize inorganic and organic laboratory analytical results for groundwater samples collected from monitoring wells screened into the weathered shale hydrostratigraphic unit. Tables 4.6-5 through 4.6-9 provide a statistical summary of groundwater analytical results for each well network management area. Tables 4.6-5 through 4.6-9 are further divided into four separate tables (denoted A through D), which provide a statistical summary for inorganic and organic (VOCs, SVOCs, and VPH-EPH) constituents. For example, Table 4.6-5A provides the statistical summary for inorganic constituent results from groundwater samples collected from the Northeast Area wells; Table 4.6-5B provides the statistical summary for VOC constituent results from groundwater samples collected from the Northeast Area wells. Each summary is subdivided into the three hydrostratigraphic units (alluvial sediments, weathered shale, competent shale).

4.6.2.1 INORGANIC CONSTITUENTS

Of the metals on the Facility's COI list, lead is the constituent of primary concern. As such, the following provides a discussion of Total Lead results from groundwater samples collected from the weathered shale monitoring wells. Note, however, the DEQ-7 standard for metals in groundwater is based on dissolved metals and not total metals. Analytical statistical summary tables for inorganic constituents are provided in Tables 4.6-5A through 4.6-9A.

4.6.2.1.1 NORTHEAST AREA

Total Lead concentrations exceeded the MDEQ standard in 7 groundwater samples from 5 monitoring wells. The highest reported concentration was 0.0987 mg/L from well P2RI-25D.

4.6.2.1.2 SOUTHEAST AREA

There were no reported Total Lead concentrations above laboratory detection limits or the MDEQ standard.

4.6.2.1.3 SOUTHWEST AREA

Total Lead concentrations exceeded the MDEQ standard in 3 groundwater samples from 3 monitoring wells. The highest reported concentration was 0.0569 mg/L from well P2RI-35S.

4.6.2.1.4 CENTRAL AREA

Total Lead concentrations exceeded the MDEQ standard in 9 groundwater samples from 4 monitoring wells. The highest reported concentration was 0.532 mg/L from well GW-H.

4.6.2.1.5 NORTHWEST AREA

Total Lead concentrations exceeded the MDEQ standard in 12 groundwater samples from 7 monitoring wells. The highest reported concentration was 0.0807 mg/L from well GW-CS.

4.6.2.2 ORGANIC CONSTITUENTS

Analytical statistical summary tables for organic constituents are provided in Tables 4.6-5(B, C, D) through 4.6-9(B, C, D).

4.6.2.2.1 NORTHEAST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **2** exceeded MDEQ standards or screening levels.

- Benzene – 22 exceedances from 6 monitoring wells. The highest reported concentration was 1.5 mg/L from well P2RI-26D.
- 1,2-Dichloroethane – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.0074 mg/L from well GW-ES.

SVOCs – Of the 37 SVOCs analyzed, **3** exceeded MDEQ standards or screening levels.

- Benzo(a)pyrene – 2 exceedances from 2 monitoring wells. The highest reported concentration was 0.00021 mg/L from wells GW-ES and P2RI-22D.
- Bis(2-Ethylhexyl)phthalate – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.22 mg/L from well P2RI-22D.
- 1-Methylnaphthalene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.012 mg/L from well P2RI-22D.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, **2** exceeded MDEQ standards or screening levels.

- C5-C8 Aliphatic – 9 exceedances from 3 monitoring wells. The highest reported concentration was 2.26 mg/L from well P2RI-26D.
- TPH – 9 exceedances from 3 monitoring wells. The highest reported concentration was 4.1 mg/L from well P2RI-26D.

4.6.2.2.2 SOUTHEAST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 4 VPH-EPH fractions/total hydrocarbons.

VOCs – Of the 28 VOCs analyzed, **0** exceeded MDEQ standards or screening levels.

SVOCs – Of the 37 SVOCs analyzed, **0** exceeded MDEQ standards or screening levels.

VPH-EPH – Of the 4 VPH-EPH fractions/total hydrocarbons analyzed, **0** exceeded MDEQ standards or screening levels.

4.6.2.2.3 SOUTHWEST AREA

Groundwater samples were analyzed for 28 VOCs, 36 SVOCs, and 4 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **0** exceeded MDEQ standards or screening levels.

SVOCs – Of the 36 SVOCs analyzed, **0** exceeded MDEQ standards or screening levels.

VPH-EPH – Of the 4 VPH-EPH fractions/total hydrocarbons analyzed, **0** exceeded MDEQ standards or screening levels.

4.6.2.2.4 CENTRAL AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **5** exceeded MDEQ standards or screening levels.

- Benzene – 25 exceedances from 6 monitoring wells. The highest reported concentration was 3.1 mg/L from well P2RI-6.
- 1,3-Butadiene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.49 mg/L from well P2RI-6.
- 1,2-Dichloroethane – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.011 mg/L from well P2RI-6.
- Toluene – 10 exceedances from 3 monitoring wells. The highest reported concentration was 4.8 mg/L from well P2RI-6.
- 1,2,4-Trimethylbenzene – 13 exceedances from 3 monitoring wells. The highest reported concentration was 0.26 mg/L from wells P2RI-6 and GW-C-47S.

SVOCs – Of the 37 SVOCs analyzed, **4** exceeded MDEQ standards or screening levels.

- Bis(2-Ethylhexyl)phthalate – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.025 mg/L from well P2RI-6.
- 1-Methylnaphthalene – 10 exceedances from 4 monitoring wells. The highest reported concentration was 0.017 mg/L from well P2RI-6.
- 2-Methylnaphthalene – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.042 mg/L from well P2RI-6.
- Naphthalene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.11 mg/L from well P2RI-6.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, **6** exceeded MDEQ standards or screening levels.

- TEH – 4 exceedances from 2 monitoring wells. The highest reported concentration was 4.6 mg/L from well P2RI-6.
- C5-C8 Aliphatic – 17 exceedances from 4 monitoring wells. The highest reported concentration was 13.2 mg/L from well P2RI-6.
- C9-C10 Aromatic – 7 exceedances from 3 monitoring wells. The highest reported concentration was 2.0 mg/L from well P2RI-6.
- C9-C-12 Aliphatic – 7 exceedances from 3 monitoring wells. The highest reported concentration was 3.45 mg/L from well P2RI-43S.
- C9-C18 Aliphatic – 4 exceedances from 2 monitoring wells. The highest reported concentration was 4.2 mg/L from well P2RI-6.
- TPH – 17 exceedances from 4 monitoring wells. The highest reported concentration was 27.8 mg/L from well P2RI-6.

4.6.2.2.5 NORTHWEST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analysis of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **6** exceeded MDEQ standards or screening levels.

- Benzene – 25 exceedances from 6 monitoring wells. The highest reported concentration was 0.4 mg/L from well P2RI-5.
- 1,3-Butadiene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.075 mg/L from well P2RI-5.
- 1,2-Dichloroethane – 3 exceedances from 1 monitoring well. The highest reported concentration was 0.019 mg/L from well P2RI-5.
- n-Hexane – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.34 mg/L from well GW-C-47S.

- 1,2,4-Trimethylbenzene – 11 exceedances from 4 monitoring wells. The highest reported concentration was 0.35 mg/L from well GW-C-47S.
- 1,3,5-Trimethylbenzene – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.14 mg/L from well GW-C-47S.

SVOCs – Of the 37 SVOCs analyzed, **4** exceeded MDEQ standards or screening levels.

- Benzo(a)pyrene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.00013 mg/L from well P2RI-5.
- 1-Methylnaphthalene – 12 exceedances from 4 monitoring wells. The highest reported concentration was 0.17 mg/L from well GW-C-47S.
- 2-Methylnaphthalene – 3 exceedances from 2 monitoring wells. The highest reported concentration was 0.29 mg/L from well GW-C-47S.
- Naphthalene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.11 mg/L from well GW-C-47S.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, **6** exceeded MDEQ standards or screening levels.

- TEH – 6 exceedances from 3 monitoring wells. The highest reported concentration was 15 mg/L from well GW-C-47S.
- C5-C8 Aliphatic – 11 exceedances from 5 monitoring wells. The highest reported concentration was 7.25 mg/L from well GW-C-47S.
- C9-C10 Aromatic – 4 exceedances from 2 monitoring wells. The highest reported concentration was 1.76 mg/L from well GW-C-47S.
- C9-C18 Aliphatic – 6 exceedances from 3 monitoring wells. The highest reported concentration was 14 mg/L from well GW-C-47S.
- C11-C22 Aromatic – 1 exceedance from 1 monitoring well. The highest reported concentration was 1.2 mg/L from well GW-C-47S.
- TPH – 13 exceedances from 5 monitoring wells. The highest reported concentration was 12.2 mg/L from well GW-C-47S.

4.6.3 COMPETENT SHALE RESULTS

The following subsections summarize inorganic and organic laboratory analytical results for groundwater samples collected from monitoring wells screened into the competent shale hydrostratigraphic unit. Tables 4.6-5 through 4.6-9 provide a statistical summary of groundwater analytical results for each well network management area. Tables 4.6-5 through 4.6-9 are further divided into four separate tables (denoted A through D), which provide a statistical summary for inorganic and organic (VOCs, SVOCs, and VPH-EPH) constituents. For example, Table 4.6-5A provides the statistical summary for inorganic constituent results from groundwater samples collected from the Northeast Area wells; Table 4.6-5B provides the statistical summary for VOC constituent results from groundwater samples collected from the Northeast Area wells. Each summary is subdivided into the three hydrostratigraphic units (alluvial sediments, weathered shale, competent shale).

4.6.3.1 INORGANIC CONSTITUENTS

Of the metals on the Facility's COI list, lead is the constituent of primary concern. As such, the following provides a discussion of Total Lead results from groundwater samples collected from the competent shale monitoring wells. Note, however, the DEQ-7 standard for metals in groundwater is based on dissolved metals and not total metals. Analytical statistical summary tables for inorganic constituents are provided in Tables 4.6-5A through 4.6-9A.

4.6.3.1.1 NORTHEAST AREA

Total lead concentrations exceeded the MDEQ standard in 3 groundwater samples from 1 monitoring well. The highest reported concentration was 0.0452 mg/L from well P2RI-27D.

4.6.3.1.2 SOUTHEAST AREA

There were no reported Total Lead concentrations above the MDEQ standard.

4.6.3.1.3 SOUTHWEST AREA

Total lead concentrations exceeded the MDEQ standard in 1 groundwater sample from 1 monitoring well. The highest reported concentration was 0.0233 mg/L from well P2RI-34D.

4.6.3.1.4 CENTRAL AREA

Total Lead concentrations exceeded the MDEQ standard in 5 groundwater samples from 3 monitoring wells. The highest reported concentration was 0.617 mg/L from well GW-A.

4.6.3.1.5 NORTHWEST AREA

Total Lead concentrations exceeded the MDEQ standard in 7 groundwater samples from 6 monitoring wells. The highest reported concentration was 1.14 mg/L from well GW-C-46DF.

4.6.3.2 ORGANIC CONSTITUENTS

Analytical statistical summary tables for organic constituents are provided in Tables 4.6-5(B, C, D) through 4.6-9(B, C, D).

4.6.3.2.1 NORTHEAST AREA

Groundwater samples were analyzed for 27 VOCs, 36 SVOCs, and 8 VPH-EPH fractions/total hydrocarbons. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 27 VOCs analyzed, **0** exceeded MDEQ standards or screening levels.

SVOCs – Of the 36 SVOCs analyzed, **5** exceeded MDEQ standards or screening levels.

- Benzo(a)pyrene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.00029 mg/L from well GW-ED.
- Bis(2-Ethylhexyl)phthalate – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.078 mg/L from well GW-ED.
- Dibenz(a,h)anthracene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.00014 mg/L from well GW-ED.
- 1-Methylnaphthalene – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.033 mg/L from well GW-ED.
- 2-Methylnaphthalene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.03 mg/L from well GW-ED.

VPH-EPH – Of the 4 VPH-EPH fractions/total hydrocarbons analyzed, **2** exceeded MDEQ standards or screening levels.

- TEH – 2 exceedances from 1 monitoring well. The highest reported concentration was 2.2 mg/L from well GW-ED.
- C9-C18 Aliphatic – 1 exceedance from 1 monitoring well. The highest reported concentration was 1.6 mg/L from well GW-ED.

4.6.3.2.2 SOUTHEAST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 4 VPH-EPH fractions/total hydrocarbons.

VOCs – Of the 28 VOCs analyzed, **0** exceeded MDEQ standards or screening levels.

SVOCs – Of the 37 SVOCs analyzed, **0** exceeded MDEQ standards or screening levels.

VPH-EPH – Of the 4 VPH-EPH fractions/total hydrocarbons analyzed, **0** exceeded MDEQ standards or screening levels.

4.6.3.2.3 SOUTHWEST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 4 VPH-EPHs. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **0** exceeded MDEQ standards or screening levels.

SVOCs – Of the 37 SVOCs analyzed, **1** exceeded MDEQ standards.

- 1-Methylnaphthalene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.0013 mg/L from well P2RI-34D.

VPH-EPH – Of the 4 VPH-EPH fractions/total hydrocarbons analyzed, **0** exceeded MDEQ standards or screening levels.

4.6.3.2.4 CENTRAL AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPHs. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **2** exceeded MDEQ standards or screening levels.

- Benzene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.012 mg/L from well GW-A.
- 1,3-Butadiene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.0003 mg/L from well P2RI-41D.

SVOCs – Of the 37 SVOCs analyzed, **6** exceeded MDEQ standards or screening levels.

- Benzo(a)anthracene – 1 exceedances from 1 monitoring well. The highest reported concentration was 0.001 mg/L from well GW-A.
- Benzo(a)pyrene – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.001 mg/L from well GW-A.
- Benzo(b)fluoranthene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.002 mg/L from well GW-A.
- Bis(2-Ethylhexyl)phthalate – 4 exceedances from 1 monitoring well. The highest reported concentration was 0.1 mg/L from well GW-A.
- 1-Methylnaphthalene – 2 exceedances from 1 monitoring well. The highest reported concentration was 0.038 mg/L from well GW-A.
- 2-Methylnaphthalene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.05 mg/L from well GW-A.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, **0** exceeded MDEQ standards or screening levels.

4.6.3.2.5 NORTHWEST AREA

Groundwater samples were analyzed for 28 VOCs, 37 SVOCs, and 8 VPH-EPHs. As described in Table 4.3-2 and Section 4.3, some wells produced insufficient groundwater to permit analyses of the full suite of constituents on the Facility's COI list.

VOCs – Of the 28 VOCs analyzed, **3** exceeded MDEQ standards or screening levels.

- Benzene – 15 exceedances from 5 monitoring wells. The highest reported concentration was 0.14 mg/L from well GW-MDF.
- n-Hexane – 2 exceedances from 2 monitoring wells. The highest reported concentration was 0.36 mg/L from well P2RI-46D.
- 1,2,4-Trimethylbenzene – 5 exceedances from 4 monitoring wells. The highest reported concentration was 0.094 mg/L from well P2RI-56DF.

SVOCs – Of the 37 SVOCs analyzed, **9** exceeded MDEQ standards or screening levels.

- Benzo(a)anthracene – 3 exceedances from 3 monitoring wells. The highest reported concentration was 0.0013 mg/L from well GW-C-46DF.
- Benzo(a)pyrene – 4 exceedances from 4 monitoring wells. The highest reported concentration was 0.002 mg/L from well GW-MDF.
- Benzo(b)fluoranthene – 3 exceedances from 3 monitoring wells. The highest reported concentration was 0.002 mg/L from well GW-MDF.
- Bis(2-Ethylhexyl)phthalate – 9 exceedances from 7 monitoring wells. The highest reported concentration was 0.58 mg/L from well GW-MDF.
- Dibenz(a,h)anthracene – 2 exceedances from 2 monitoring wells. The highest reported concentration was 0.00044 mg/L from well GW-C-46DF.
- Indeno(1,2,3-cd)pyrene – 1 exceedance from 1 monitoring well. The highest reported concentration was 0.00074 mg/L from well GW-C-46DF.
- 1-Methylnaphthalene – 16 exceedances from 9 monitoring wells. The highest reported concentration was 0.098 mg/L from well GW-MDF.

- 2-Methylnaphthalene – 4 exceedances from 4 monitoring wells. The highest reported concentration was 0.13 mg/L from wells P2RI-46DFU and GW-MDF.
- Naphthalene – 2 exceedances from 2 monitoring wells. The highest reported concentration was 0.12 mg/L from well GW-MDF.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, 5 exceeded MDEQ standards or screening levels.

- TEH – 4 exceedances from 3 monitoring wells. The highest reported concentration was 8.8 mg/L from well P2RI-46DFU.
- C5-C8 Aliphatic – 12 exceedances from 4 monitoring wells. The highest reported concentration was 4.2 mg/L from well P2RI-56DF.
- C9-C18 Aliphatic – 3 exceedances from 2 monitoring wells. The highest reported concentration was 7.1 mg/L from well P2RI-46DFU.
- C9-C-36 Aliphatic – 1 exceedance from 1 monitoring well. The highest reported concentration was 1.4 mg/L from well P2RI-46DFL.
- TPH – 12 exceedances from 4 monitoring wells. The highest reported concentration was 5.96 mg/L from well P2RI-56DF.

4.7 SOIL ANALYTICAL RESULTS

Samples of the soil cuttings produced during installation of monitoring well PA-5R, the P2RI-prefix wells including the replacement wells, the routine groundwater monitoring wells (designated as GW-letter), and the sonic boring conversion wells (designated as GW-sonic boring identifier) were submitted to the analytical laboratory for laboratory analyses of the full COI list (Table 2.1-1) for soils. Typically, soil samples were collected from the depth interval at which the well was screened; in some cases (where additional depth-specific data was desired to allow better characterization of the subsurface), more than one depth interval was sampled from a well boring. The subsurface soil cutting analytical results are summarized in Table 4.7-1. Full analytical results are tabulated in Tables 4.7-2 through 4.7-5. Laboratory reports are provided as Appendix 4-F.

For each analyte, Table 4.7-1 lists the frequency of detection, number of subsurface soil screening level exceedances (direct contact and/or MTGW, as applicable), the maximum detected concentration, and the location/sample depth in which the maximum concentration was reported. Note that for purposes of preparing that data summary, duplicate

samples were excluded in order to preserve an accurate count of samples collected. Duplicate sample results are included in the soil data tables and on the laboratory reports.

For the soil cuttings data summary provided below, inorganic and organic constituents are summarized if the laboratory reported concentration exceeded the subsurface soil MTGW screening levels. Note that in Table 4.7-1, there are some instances where a constituent exceeds the subsurface soil MTGW screening level but was not detected by the laboratory above the method detection limit. This is due to the laboratory method detection limits being greater than subsurface soil MTGW screening level. These data are not discussed below but are preserved in Table 4.7-1.

Inorganics – Of the 16 inorganics analyzed, **4** exceeded the MTGW screening levels.

- Arsenic – 117 exceedances from 117 soil samples. The highest reported concentration was 35 J mg/kg from well P2RI-15 (5-10 ft-bgs).
- Barium – 13 exceedances from 117 soil samples. The highest reported concentration was 1260 mg/kg from well P2RI-45E (13-14 ft-bgs).
- Cobalt – 117 exceedances from 117 soil samples. The highest reported concentration was 14.4 mg/kg from well P2RI-5S (11-12 ft-bgs).
- Selenium – 7 exceedances from 117 soil samples. The highest reported concentration was 10.6 mg/kg from well GW-MS (14-15 ft-bgs).

VOCs – Of the 27 VOCs analyzed, **5** exceeded the MTGW screening levels.

- Benzene – 16 exceedances from 117 soil samples. The highest reported concentration was 2.53 mg/kg from well P2RI-6 (24-27 ft-bgs).
- Hexane – 1 exceedance from 117 soil samples. The highest reported concentration was 29.5 mg/kg from well P2RI-4S (12-15 ft-bgs).
- Toluene – 1 exceedance from 117 soil samples. The highest reported concentration was 13.3 mg/kg from well P2RI-6 (24-27 ft-bgs).
- 1,2,4-Trimethylbenzene – 16 exceedances from 114 soil samples. The highest reported concentration was 8.97 mg/kg from well P2RI-4S (12-15 ft-bgs).
- 1,3,5-Trimethylbenzene – 8 exceedances from 114 soil samples. The highest reported concentration was 4.65 mg/kg from well P2RI-4S (12-15 ft-bgs).

SVOCs – Of the 36 SVOCs analyzed, **3** exceeded the MTGW screening levels.

- Tetraethyl Lead – 1 exceedance from 117 soil samples. The highest reported concentration was 0.145 J mg/kg from well GW-CDF (109-110 ft-bgs). Note, this was the only reported concentration above the laboratory method detection limit.
- 1-Methylnaphthalene – 46 exceedances from 117 soil samples. The highest reported concentration was 1.24 mg/kg from well P2RI-46S (18-19 ft-bgs).
- 2-Methylnaphthalene – 1 exceedance from 117 soil samples. The highest reported concentration was 2.59 mg/kg from well P2RI-46S (18-19 ft-bgs).

VPH-EPH – Of the 7 VPH-EPH fractions/total hydrocarbons analyzed, **3** exceeded the MTGW screening levels.

- C5-C8 Aliphatic – 3 exceedances from 117 soil samples. The highest reported concentration was 1660 J mg/kg from well P2RI-4S (12-15 ft-bgs).
- C9-C10 Aromatic – 6 exceedances from 117 soil samples. The highest reported concentration was 153 J mg/kg from well P2RI-32S (7-10 ft-bgs).
- C11-C22 Aromatic – 2 exceedances from 7 soil samples. The highest reported concentration was 770 J mg/kg from well P2RI-31S (9.5-10.5 ft-bgs).

4.8 INVESTIGATION OF MUNICIPAL WATER SUPPLY

The Town of Sunburst water supply originates from two groundwater wells located approximately 8 and 14 miles to the west of Sunburst. Groundwater from these two wells is mixed and treated at a chlorine building/pump house, then pumped 8 miles via an underground pipeline to an above-ground holding tank. The above-ground holding tank is located southwest of the high school, and routed to homes and businesses through a network of underground supply lines. CEMC gathered information from Sunburst town officials to evaluate the condition of the current water supply system. Specific information on the age and condition of the current supply network is generally sparse, and repairs and/or replacement of water supply lines have been undertaken at numerous times over the years within town. Evidence of leaking below-ground supply lines exists within the town (saturated areas on the ground surface and within streets), and water overflow at the above-ground holding tank has been observed to occur periodically by CEMC personnel and others. Flow-gauging meters are not used at the outlet of the holding tank, individual homes, or businesses, and therefore it is not possible for the Town of Sunburst to reliably track water usage, or any potential leaks within the system.

4.8.1 PHASE II REMEDIAL INVESTIGATION ACTIVITIES CONDUCTED (2008/2009)

The SOW of the Phase II RI was outlined by MDEQ in a correspondence dated May 16, 2008. MDEQ required CEMC to conduct an investigation to determine if leakage from the Town of Sunburst's water tank and supply lines may potentially be influencing subsurface water-bearing zones and contaminant migration at the Facility. During 2008, 2009, and again in 2011, CEMC conducted an investigation to evaluate the potential subsurface input of municipal groundwater into water-bearing zones beneath the Town of Sunburst. As part of this investigation, CEMC reviewed available historical utility maps as well as any documents that would provide information regarding the potential leakage of the town water tank. CEMC also supplemented the current scope of groundwater investigations to analyze groundwater samples for regulated drinking water organics and total trihalomethanes (TTHM). Those "disinfection byproducts" are typically a result of reactions between organic constituents and chlorine utilized to disinfect drinking water. Therefore, the presence of TTHMs would suggest that drinking water is infiltrating into the water-bearing zones.

4.8.1.1 HISTORICAL DOCUMENT REVIEW

The engineering, surveying, and planning firm Kadrmas, Lee, and Jackson (KLJ, Helena, Montana) conducted an investigation for the Town of Sunburst to evaluate the municipal water and sanitary sewer system to:

- Determine capacity for future growth
- Evaluate potential system expansion to serve the since-built Homeland Security Facility and a potential housing development projected to consist of approximately 40 residential homes on undeveloped land on the west side of the city

In March 2008, KLJ submitted a report to the Town of Sunburst titled *Water and Sanitary Sewer System Preliminary Engineering Report* (Kadrmas 2008), which provided a summary of the investigation as well as a recommendation for infrastructure improvements. The investigation concluded that there appears to be significant water loss in the sewer and/or water systems within the Town of Sunburst. That conclusion was based on comparison of water usage and the sewage lagoon design capacity. The sewage lagoon is located approximately 1 mile southeast of town on the south shore of the playa lake, and was designed for an average flow of 51,400 gallons per day (gpd). KLJ reported there was an average daily usage of approximately 90,000 gpd during winter and 300,000 gpd in the summer, as gauged at the pump house west of town. It was also reported that the expected usage for a municipality the size of Sunburst would be 40,000 gal/day during winter.

Per American Water Works Association (AWWA) statistics, daily indoor per capita water use in the typical single family home is 69.3 gallons. Assuming Sunburst has 400 residents, that would translate to 28,000 gpd in the winter,

which is fairly consistent with the 40,000 gpd referenced by KLJ. Greater usage in the summer would be expected due to lawn irrigation, car washing, etc. These numbers for winter usage suggest system losses of about 34-70 percent, assuming that Sunburst residents use somewhere between the average amount of water and 2 times the average. (Source AWWA:

<http://www.drinktap.org/consumerdnn/Home/WaterInformation/Conservation/WaterUseStatistics/tabid/85/Default.aspx>).

Assuming that the flow-gauging meter at the pump house is accurate, 90,000 gallons per day far exceeds the sewage lagoon capacity of 51,400 gallons per day. Currently, the Town of Sunburst does not have flow-gauging meters at the outlet of the holding tank, individual homes, or businesses so it is difficult to verify water usage.

KLJ concluded that the impacts of the proposed developments around the Town of Sunburst will rely on the results of verifying the water usage summarized above and no further action should be taken until the water usage is verified. There appears to be sufficient water supply, but the sanitary sewer system may be failing if the water usage is as high as reported. KLJ recommended that the town install new flow-gauging meters (estimated cost of \$20,000) at the chlorine building and the outlet of the water holding tank.

4.8.1.2 DRINKING WATER ANALYSIS

CEMC supplemented the current scope of investigations to analyze for trihalomethanes in groundwater as part of the routine quarterly monitoring event conducted in May 2009. Groundwater samples collected were analyzed for the following trihalomethane compounds: bromodichloromethane, bromoform, chloroform, and dibromochloromethane by USEPA Method 524.2. The groundwater samples collected from wells located both within and outside of the established plume boundary were analyzed for those compounds to assist in the evaluation of whether or not Sunburst town water is present in the shallow groundwater-bearing zone. Analytical results were below laboratory detection limits for all compounds.

As discussed in the Phase II RI Work Plan, the groundwater underlying the Town of Sunburst may have a high buffering capacity (ability to neutralize the aliquot of acid added to each sample), which leads to high sample pH. Groundwater with a high buffering capacity can normally be attributed to excessive sample foaming and the inability to maintain a low pH. This can result in the sample's inability to maintain a pH<2 per the method requirement for USEPA Method 524.2. In accordance with the USEPA Method 524.2, groundwater samples with a pH>2 must be analyzed within a 24-hour time period. This requirement is to prevent loss of volatiles in groundwater samples. Rejection of data for samples previously analyzed for these constituents was required for a large portion of the undetected results since volatilization may have caused false negative results in the samples. Therefore, based on this

historical evidence of excessive sample foaming, preservation was not added to the groundwater samples in September 2011. The samples were instead shipped overnight to the laboratory and analyzed within 24 hours of collection. The analytical results for samples collected for USEPA Method 524.2 in September 2011 were not rejected.

4.8.2 RESULTS OF PHASE II REMEDIAL INVESTIGATION

Information gathered by CEMC as part of the Phase II RI during 2008 and 2009, indicated the likelihood of a potential leak from the town water tank, supply lines, or sanitary sewage system. However, it was difficult to accurately determine the location(s) of the possible leak(s), due to the current flow gauging system and lack of record keeping by the Town of Sunburst. To assist in assessing whether the city water tank was leaking, CEMC converted the following sonic borings into monitoring wells: GW-C-46S, GW-C-46DF, GW-CS, GW-CD, GW-CDF, GW-D, and GW-H.

CEMC proposed to collect groundwater samples from the abovementioned monitoring wells for analysis of TTHM constituents. However, TTHM was not analyzed for monitoring wells GW-C-46DF, GW-CDF, and GW-D during the September 2011 quarterly sampling event due to insufficient water being present in the well. Laboratory analytical results from the groundwater samples collected from monitoring wells GW-C-46S, GW-CS, GW-CD, and GW-H were below detection limits for all TTHM constituents (Table 4.8-1).

As mentioned above, it is difficult to determine whether the potential leak is from the town's water tank, supply lines, sanitary sewage system, or a combination of all of these infrastructure components. The contaminant plume has been relatively stable since 1957, indicating that potential leakage from the municipal system has not accelerated contaminant migration at the Facility. Additional activities, if any, will be dependent on whether the Town of Sunburst undertakes infrastructure improvement, which includes the installation of new flow-gauging meters at the chlorine building and at the outlet of the water holding tank. Absent infrastructure improvement, additional investigation activities are not likely to produce any more conclusive results.

4.9 GROUNDWATER CLASSIFICATION

As discussed in Section 1.3.2, CEMC has evaluated groundwater data from 1990 through 2011 to assess the classification of groundwater at and near the Facility. Based on that evaluation, the shallow groundwater beneath Sunburst meets the criteria for classification as Class IV groundwater as specified in Montana Water Quality Rule 17.30.1006, Section (4). Appendix 1-C of this Report presents an evaluation of groundwater data to allow for a determination of groundwater classification.

4.10 HYDROCARBON FORENSICS

CEMC has conducted LNAPL monitoring and recovery at selected locations on a monthly basis since December 2007, in accordance with the MDEQ-approved work plan entitled *Addendum No. 2 to Revised Limited Scoping Investigation(LSSI) Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana*. LNAPL has intermittently been observed in monitoring wells within the network, and samples have been collected and submitted for forensic analyses. In addition, groundwater samples have been collected from selected wells located within town and submitted for forensic analyses on an annual basis since 2009. Soil samples have also been collected from select locations for laboratory analyses. This section describes the sample collection and analytical methods. The data is evaluated and discussed in the context of the Facility's CSM in Section 7.2.2.3.

The objective of the LNAPL forensic analyses was to better understand the chemical nature of LNAPL impacts and identify any potential chemical variation in the different LNAPLs present. The chemical data can assist in the identification of potential source areas, as well as help delineate areas impacted by particular sources. In addition, understanding the chemical makeup and release history can help in understanding the level of risk that impacts may pose on human health and the environment, and may aid in the design and selection of remedial alternatives.

Groundwater flow and LNAPL migration that occurs in fractured media will follow a complex pathway based on the characteristics of the rock, including fracture density, orientation, and aperture distribution. Understanding the occurrence of LNAPL and the composition of dissolved impacts associated with the LNAPLs at the former refinery will assist with efforts to mitigate the impacts in the most logical and efficient manner possible.

Sampling and Analysis Methods - CEMC has been investigating LNAPL impacts at the Facility since 2006. When LNAPL is observed in a location that has not been sampled previously, and if sufficient volume is available, a sample is collected for forensic analysis. The date of collection for each sample submitted by CEMC for forensic analyses are given in Table 4.10-1. The chemical characteristics of the samples are discussed and compared in detail in the hydrocarbon forensic lab reports (Appendix 4-F).

CEMC has utilized Alpha Woods Hole Laboratory (Mansfield, Massachusetts) and Chevron's Environmental Technology Company laboratory (Richmond, California) to complete forensic analyses. Interpretation of analytical results from Alpha Woods Hole Laboratories are interpreted and reported by NewFields Environmental Forensics Practice, LLC. Copies of all laboratory analytical and data interpretation reports are included in Appendix 4-F. The chemical forensic methods used in these analyses are those described by Douglas et al. (2007) and Stout et al. (2006). The methods used included:

- Modified USEPA Method 8015B
- Modified USEPA Method 8270C for semi-volatile compounds
- Modified USEPA Method 8270C for organic lead speciation
- Modified USEPA Method 8260 for volatile “PIANO” compounds

Groundwater and LNAPL samples are each analyzed using modified USEPA Method 8015B and modified USEPA Method 8270C for semi-volatile compounds. The 8015B method is a gas chromatography-flame ionization detection (GC/FID) analysis providing the concentrations of total petroleum hydrocarbons (TPH, C9-C44) and a targeted series of *n*-alkanes and acyclic isoprenoids (e.g., pristane and phytane) in the groundwaters and LNAPLs, as well as a GC/FID (C8 to C44) “fingerprint” of the hydrocarbons within each sample. The 8270C method is a gas chromatography-mass spectrometry (GC/MS) operated in the selected ion monitoring mode (SIM) analysis providing the concentrations of ~60 decalins, PAHs, and sulfur-containing aromatics and the qualitative distributions terpane and sterane biomarkers.

LNAPL (only) samples are also analyzed for the concentration of organic lead species historically used in automotive gasoline using modified USEPA Method 8270C for organic lead speciation. Groundwater or groundwater extracts are not amenable to this analysis. The density (g/mL) of each LNAPL was determined gravimetrically, which allowed for the concentration of any organic lead to be converted to a *gram lead per gallon* (glpg) metric. Aliquots of the groundwater and LNAPLs were also analyzed using modified USEPA Method 8260 for volatile ‘PIANO’ compounds. PIANO is an acronym for the five hydrocarbon compound classes comprising petroleum product, *viz.*, paraffins, isoparaffins, aromatics, naphthenes, and olefins. This GC/MS analysis provided the concentration of 88 volatile compounds typically found in automotive gasoline and other light petroleum products, including ether-oxygenate additives (MTBE et al.) and other gasoline additives historically used (e.g., lead scavengers).

Soil samples submitted were extracted and analyzed by gas chromatography using a flame ionization detector to determine the hydrocarbon composition, and gas chromatography mass spectroscopy for other compound identification.

The locations from which samples have been collected for hydrocarbon forensic analyses are shown on Figure 4.10-1, along with the date(s) of sample collection.

5.0 SURFACE WATER AND SEDIMENT

Surface water drainage in the Sunburst area is poorly developed and characterized by small, ephemeral streams that flow only after periods of sufficient precipitation or snow melt into intermittent un-drained depressions. Due to the arid climate, water that does collect in drainages quickly evaporates, often leaving behind alkali deposits. Note that these characteristics tend to limit sediment deposits. Investigation activities have demonstrated true benthic sediment does not occur in any of the surface drainages associated with the former refinery, with the exception of Surface Drainage 01. However, the term “sediment” continues to be used to maintain consistency with the terminology used in the MDEQ May 16, 2008 SOW.

At the Facility, a total of eight drainages are identified where surface water runoff could occur during precipitation events or periods of snow melt. Groundwater seep areas were identified in one of the drainages (Surface Drainage 01). Inspection and sampling of drainages present at the Facility were conducted to provide data for updating the Facility’s CSM, and to determine the nature and degree of Facility-related impacts in those areas. The drainages at the Facility are identified as Surface Drainages (SD) 01 through 08, and are described as follows:

- SD01: Large surface drainage located approximately 500 feet northwest of Tank Berm 34
- SD02: Large surface drainage located along the southern edge of the tank farm
- SD03: Large surface drainage located approximately 1,000 feet west of the northwestern cluster of former tank berms
- SD04 through SD08: Five smaller surface drainages located in the eastern portion of the Facility

The locations of these eight drainages are shown on Figure 5.1-1. The Facility’s surface water and sediment sampling investigation involved these eight drainages and included the following activities:

- Visual inspection of the eight surface drainages to identify and sample possible groundwater seeps or springs on a quarterly basis, increasing to monthly following periods of snow melt and during the months of typically higher precipitation (May – July)
- Collection of sediment samples from the eight surface drainages
- Collection of water samples on a quarterly basis (for one year) from groundwater seep areas in SD01, with monitoring/sampling conducted monthly during the historically higher precipitation months (May – July)

Visual inspection of the eight drainages, initial sediment sampling, and the first surface water monitoring/sampling event all were performed during the first quarter of 2010. The Facility-wide surface water monitoring/sampling program continued through the fourth quarter of 2010. An additional surface water sample was collected from one drainage (SD08) in 2011, following a precipitation event and at the request of the owner of livestock located on former refinery property. Details of this sampling event are discussed in Section 5.2. Additional investigation and sampling activities were also performed in SD01 during 2012 and 2013, related to performance of an ecological risk assessment for the Facility, and also related to monitoring of hydrocarbon impacts to groundwater seeps in the drainage. Details of these data collection activities (through end of 2012) are presented in this chapter; more detailed discussion of other data collection activities completed during 2012 and 2013 is included in Chapter 8.0 of this Report.

Data tables associated with this chapter include laboratory analytical results from each drainage identified and investigated at the Facility. Data generated by activities conducted during the first quarter of 2010 were reported in the CSM Update Addendum and are presented again in the following subsections. Results from activities completed after the first quarter 2010 and through the fourth quarter of 2012 also are presented in this Report.

5.1 SURFACE WATER

The following sections discuss activities conducted to investigate surface water conditions in the eight drainages associated with the Facility and present the associated results. Investigations were conducted in accordance with the procedures and methods described in the CSM Work Plan and Phase II RI Work Plan FSP, and summarized in Section 2.1.3 of this Report. Surface water samples were analyzed for constituents on the Facility's COI list for groundwater and surface water (see discussion in Section 2.1.5 and Table 2.1-2). Samples typically were designated with a "SD" prefix, the surface drainage number, and a suffix to differentiate between surface water and sediment samples. Sample naming convention used varies somewhat between samples collected pre-2012 and those collected during 2012. These variations include the following:

- Initial samples collected included the term "DRAINAGE" in the sample ID, in addition to the surface drainage number (e.g., "DRAINAGE 01").
- Subsequent sample IDs were shortened to include "SD" and the surface drainage number (e.g., "SD08"), but inserted the date of sample collection into the surface water suffix "SW", (e.g., "SD08-030310SW").

- The terms “NSUMP” and “SSUMP” were included in sample IDs following installation of sumps to facilitate collection of surface water (due to the minimal depth of the water and to minimize or eliminate sediment within surface water samples collected from SD01 (e.g., “SD01-SSUMP-SW”).
- Sequential numbering within the “SW” suffix was used when multiple samples were collected from a seep or area of surface water (e.g., “SD01-052110-SW2”).

Naming convention utilized during the surface water investigation is presented in Table 2.1-3. Details regarding specific inspection and sampling events are presented in the following section.

5.1.1 INVESTIGATION AND SAMPLING

Due to the infrequent and intermittent presence of surface water in the drainage channels identified at the Facility, surface water sampling events could not follow a specific schedule. Rather, efforts were made to collect samples as soon as possible following a precipitation event of sufficient magnitude to cause surface water runoff, and the observation of surface water in a drainage channel. Water samples were collected from within the main portion of a drainage where surface water was present. In the case of SD01, sampling locations were chosen down-gradient of or adjacent to groundwater seep locations.

Following is a summary listing of the surface water sampling events that were conducted during the course of the Phase II RI. Surface water sample locations referenced are shown on Figure 5.1-2. Surface drainage inspection forms, notes, and associated equipment calibration forms are included in Appendices 5-A and 5-B. Photographs taken during inspection of surface drainages are presented in Appendix 5-F.

- SD01, SD02, and SD03 were inspected in early February 2010. No surface water was observed in those drainages, including at the known groundwater seep areas within in SD01, most likely due to the frozen ground surface. However, on February 12, 2010, surface water runoff resulting from significant snow melt was observed in SD01. A surface water sample (DRAINAGE 01) was collected and submitted for laboratory analysis.
- On March 3, 2010, SD04 – SD08 were inspected, during which water was observed in SD08, most likely from runoff due to snow melt. A surface water sample (SD08-030310SW) was collected and submitted for laboratory analysis.
- Due to the presence of runoff in SD08, drainages SD01, SD02, and SD03 were also inspected on March 3, 2010. Surface water was present in these drainages, again likely due to runoff caused by snow melt. Surface water samples were collected from each drainage area (SD01-030310SW, SD02-030310SW, and SD03-030310SW) and submitted for laboratory analysis.

- On March 18, 2010, surface water was observed in the area of the upstream groundwater seep within SD01, again suspected to be runoff from snow melt. A surface water sample (SD01-031810-SW) was collected and submitted for laboratory analysis. SD02 and SD03 were also inspected at that time and no surface water was observed during the inspection.
- All eight surface drainages were inspected on April 22, 2010. Surface water suspected to be related to the upstream groundwater seep area (located near the intersection of the two branches of the drainage) was observed in SD01 and noted as extending approximately 500 feet down the drainage to a point just upstream of the remnants of a small earthen dam (which has been eroded and breached). Due to detections of a number of organic and inorganic constituents in prior samples from SD01 (some at concentrations above applicable MDEQ Circular 7 surface water standards), a sample (SD01-042210-SW) was collected during this event and submitted for laboratory analysis. Standing water was also noted at the eastern end of SD08, in a depression behind a small earthen dam. Due to non-detection of any organic constituents and detected concentrations of inorganic constituents being below applicable DEQ-7 surface water standards in the prior sample collected from SD08, a sample was not collected during this event for laboratory analysis. All other drainages were noted as being dry during the inspection.
- On April 23, 2010, SD01 was inspected following a rainfall event. Surface water was observed to be flowing within the channel downstream of the former earthen dam location. A surface water sample was collected (SD01-042310-SW) and submitted for laboratory analysis.
- All eight drainages were inspected on May 21, 2010. Surface water was observed within SD01 at the two groundwater seep locations and extending a few feet beyond the confluence of the west and south branches of the drainage. A surface water sample was collected from just beyond the confluence (SD01-052110-SW1) and submitted for laboratory analysis. An area with standing water was also observed, upstream of the former earthen dam. A sample was collected (SD01-052110-SW2) and submitted for laboratory analysis. The other seven drainages at the Facility were inspected and were noted as being dry.
- All eight drainages were inspected on June 16, 2010, following a rainfall event. Only two drainages (SD01 and SD07) contained standing or flowing water. Surface water samples were collected from the same two locations within SD01 (SD01-061610SW1, SD01-061610SW2) that were sampled on May 21, 2010. Surface water was also observed in SD07. A surface water sample (SD07-061610SW) was collected and submitted for laboratory analysis.

The summary of inspection and sampling activities at the Facility confirmed that the presence of surface water within drainages is sporadic and temporary, and successful collection of surface water samples is highly dependent upon the

amount of elapsed time between a significant precipitation event and sampling. However, as visual inspections and sampling progressed during the course of the Phase II RI, it became apparent that SD01 contained surface water more frequently than the other Facility drainages, as result of groundwater seepage.

Due to the potential for excessive suspended sediment to bias high reported constituent concentrations (especially concentrations of metals), alternate sampling methods were subsequently employed in SD01 to allow for collection of more representative water samples from the groundwater seep areas. Collection “sumps” comprised of lidded plastic buckets (described in Section 2.1.3.1) were installed at the two seep sample collection points (see Figure 5.1-2) within SD01, with the intent that future water samples would be collected from the sumps.

Inspection and sampling of drainages continued after June 2010, as described in the following summary:

- All eight drainages were inspected on July 20, 2010, following rainfall from the previous day. Surface water was observed in two of the eight drainages (SD01 and SD03). Both sumps in SD01 were sampled (SD01-072010SW1, SD01-072010SW2). A small area of standing water was noted in SD03 in the area behind an earthen dam. A sample of this standing surface water was collected (SD03-072010SW) and submitted for laboratory analysis. The remaining six surface drainages did not contain surface water.
- Seven of the eight drainages were inspected on August 10, 2010, following significant rainfall that day. Saturated/muddy ground conditions in the tilled agricultural field between the tank farm and SD03 prevented access to/inspection of that drainage. Surface water was observed flowing in two of the seven drainages that were inspected, SD01 and SD07. Samples were collected from surface water that had accumulated in the two sumps within SD01 (SD01-NSUMP-SW, SD01-SSUMP-SW), with surface water observed as flowing a short distance past the southernmost sample location (SD01-SSUMP-SW). No surface water flow was noted at the northern sample location (SD01-NSUMP-SW). A small area of flowing/standing water was observed in SD07 at the time of inspection. However, when staff returned to the area with sample containers and field equipment (approximately 20-30 minutes after inspection of drainages was completed), no surface water was present (i.e., the soil had absorbed the water) and no sample was collected. A sediment sample was collected from the location where standing water had been observed, and is discussed further in Section 5.2.1.
- On August 19, 2010, SD03 was inspected as drier surface conditions allowed for access to the drainage. No surface water was observed during the inspection.
- On September 9, 2010, seven of the eight drainages were inspected following precipitation earlier in the day. Muddy ground surface conditions again prevented access to SD03. Flowing surface water was observed only in SD01. Samples of surface water (SD01-092010SW1 and SD01-092010SW2) were collected from the near vicinity

of the two sumps located within the drainage, instead of from within the sumps. As a result, those samples may have contained significant quantities of suspended sediment. Standing water was observed in SD04 and SD07. The standing water in SD04 and SD07 was not sampled during this event, as no water was present when staff returned to the locations after completing the site-wide inspection.

- On September 14, 2010, SD03 was inspected as drier surface conditions allowed for access to the drainage. No surface water was observed during the inspection.
- All eight drainages were inspected on December 14, 2010. No surface water was observed within any of the drainages. In SD01, both sampling sumps contained water, and samples (SD01-SSUMP-SW and SD01-NSUMP-SW) were collected and submitted for laboratory analysis.

Surface water sample locations are shown on Figure 5.1-2. Analytical data are presented in Tables 5.1-1 through 5.1-4, with discussion included in Section 5.1.5. Surface drainage inspection forms and notes are included in Appendix 5-A, while laboratory analytical reports and data validation reports are provided in Appendices 5-C and 5-D, respectively.

The surface water sampling program presented in the CSM Work Plan and the Phase II RI Work Plan was completed in December 2010. However, an additional surface water sample was collected from SD08 on May 21, 2011, when the owner of livestock kept on the property reported a dead calf to staff. A water sample (SD08-052111SW) was collected at the terminus of SD08 and submitted for laboratory analysis.

5.1.2 SURFACE DRAINAGE 01

Two groundwater seep areas were identified within SD01 during initial inspections of the Facility drainages. Groundwater seeps were identified by the presence of alkali/evaporative deposits, saturated soils, standing water, and the presence of distinctive (alkali resistant) vegetation. SD01 is the only drainage at the Facility with groundwater seeps; the two seep areas are described as follows:

- A larger seep area located along portions of the two upper branches (a southern trending branch and a western trending branch) of the drainage and extending down channel to a point approximately 100 feet beyond their junction
- A smaller seep area located at the junction of a side channel and the main channel of the drainage (approximately 800 feet down channel from the junction of the two upper branches)

To obtain data to complete an ecological risk assessment, the document *Work Plan for Collection of Additional Water Samples at Surface Drainage 01, Former Texaco Sunburst Works Refinery, Sunburst, Montana* was submitted to

MDEQ in March 2012 (CEMC 2012a). This work plan required additional surface water samples, and installation of six sampling points (piezometers). To expedite installation of the piezometers and ensure sampling could be completed prior to the end of the first quarter 2012, MDEQ verbally approved the work plan and confirmed that approval via correspondence dated April 4, 2012.

Piezometers were installed following the procedures described in the approved work plan in late March, four in the groundwater seep area and two in areas where groundwater does not appear to discharge. Their purpose was to collect water in the hyporheic zone (the zone of mixing between discharging groundwater and surface water). Piezometer locations (identified as "SD01-TP-#") are shown on Figure 5.1-2.

Four of the six piezometers (those four installed in groundwater seep areas) were sampled in late March. The two piezometers installed in SD01 outside of groundwater seep areas were dry. Sampling methodology used with the piezometers differs from that used in collecting surface water samples. Low-flow groundwater sampling methods, summarized in Section 2.1.2, were used to collect groundwater samples from the piezometers.

Benzene, 1,2-dichloroethane, and total petroleum hydrocarbon were detected in piezometers SD01-TP-01 and SD01-TP-03, at concentrations above their applicable DEQ-7 groundwater standards. Confirmation sampling occurred in April 2012, and laboratory analytical results indicated that concentrations decreased from those observed in the March 2012 sampling event. However, in piezometer SD01-TP-01, benzene was detected at a concentration above the DEQ-7 groundwater standard.

Additional water samples were obtained in May 2012:

- At four piezometers which had water present
- Surface water samples from locations in close proximity to piezometers SD01-TP-01 and SD01-TP-03
- Downstream of those locations where surface water was present at time of sampling

The purpose of the May 2012 sampling effort was to determine if constituents present in the hyporheic zone water are also present in surface water within the drainage. Water samples were submitted for laboratory analysis of VOCs and VPH. Laboratory analytical results indicate that constituents detected in piezometer SD01-TP-01 are present in proximal surface waters. Benzene was detected at a concentration above the DEQ-7 groundwater standard in this surface water sample (collected proximal to piezometer SD01-TP-01). No VOC or VPH constituents were detected in the surface water samples collected proximal to piezometer SD01-TP-03, or surface water collected downstream in the drainage.

On June 6, 2012, CEMC presented a letter to MDEQ, titled “*Data Summary and Proposed Monitoring Activities, Surface Drainage 01*” (CEMC 2012e), to update MDEQ on data collected from SD01 since submittal of the March 26, 2012 work plan, and propose additional measures. Also, in conjunction with the quarterly monitoring, CEMC suggested that further monitoring be conducted after periods of significant rainfall (i.e., 0.5-inches or greater in a 24-hour period) to assess the extent of surface water runoff and determine its correlation with precipitation.

The SD01 monitoring plan was revised in July 2012, and approved August 16, 2012. In accordance with that work plan, piezometers were to be sampled and analyzed on a quarterly basis and whenever surface water is present, most often after significant precipitation or snowmelt events. Surface water samples were also collected in conjunction with the piezometer sampling.

The 2012 sampling events completed for SD01 are summarized below. As noted previously, water samples have been collected on a quarterly basis (as well as during precipitation events) from piezometers installed in late March 2012 within the two groundwater seep areas in SD01, as well as from areas where surface water has been present at that time. The naming convention used for water samples collected from the piezometers within SD01 include “TP” in the sample name (for example, “SD01-TP-01”; see Table 2.1-3). Surface water and groundwater (hyporheic) zone samples collected in conjunction with the 2012 assessment activities include:

- On March 26, 2012, groundwater samples were collected from the four piezometers (SD01-TP-01, SD01-TP-02, SD01-TP-03, and SD01-TP-04) with water present (i.e., SD01-TP-05 and SD01-TP-06 were dry) and submitted for laboratory analysis of all constituents included on the Facility’s groundwater/surface water COI list.
- On April 26, 2012, groundwater samples were collected from piezometers SD01-TP-01 and SD01-TP-03 and submitted to the laboratory for analysis of VOCs and VPH, in order to confirm the results from the March 2012 sampling event. VOCs were detected at concentrations above applicable MDEQ groundwater standards in the March 2012 samples collected from these two locations.
- On May 3, 2012, additional groundwater samples were collected from the four piezometers with water present, as well as surface water samples (SD01-05032012SW1, SD01-05032012SW2, SD01-05032012SW3) from locations in close proximity and downstream of SD01-TP-01 and SD01-TP-03. The purpose of the May 2012 sampling effort was to determine whether constituents present in the hyporheic zone water were also present in surface water within the drainage. All of the samples were submitted for laboratory analysis of VOCs and VPH.
- On June 6, 2012, surface water samples were collected (SD01-06062012SW1, SD01-06062012SW2, and SD01-06062012SW3) from the three sample locations utilized on May 3, 2012.

- On July 2, 2012, groundwater samples were collected from the four piezometers with sufficient water (SD01-TP-01, SD01-TP-02, SD01-TP-03, and SD01-TP-04). Samples were submitted to the laboratory for analysis of VOCs and VPH. These samples were collected as part of the second quarter 2012 inspection/sampling for SD01.
- On July 4, 2012, surface water samples were taken from six locations within SD01. Three of the locations (SD01-SW01, SD01-SW02, and SD01-SW03) corresponded to the sample locations utilized on May 3 and June 6, 2012. These samples were collected as part of the second quarter 2012 inspection/sampling for SD01. Three other locations (SD01-SW04, SD01-SW05, and SD01-SW06), within the southwestern branch of SD01, were selected for background determination sampling purposes (see Chapter 8.0 for discussion of background determination sampling).
- On July 27, 2012, following a significant precipitation event (site weather station recorded 0.76 inches of precipitation on July 26, 2012 between 2045 and 2100 hours), three surface water samples (SD01-SW01, SD01-SW02, and SD01-SW03) were collected from the same locations utilized on May 3, June 6, and July 4, 2012.
- On September 13, 2012, groundwater samples were collected from each of the four piezometers containing sufficient water (SD01-TP-01, SD01-TP-02, SD01-TP-03, and SD01-TP-04), as well as two of the three surface water locations utilized throughout 2012 (SD01-091312-SW1 and SD01-091312-SW2). These samples were collected as part of the third quarter 2012 inspection/sampling for SD01.
- On November 15, 2012, surface water samples were collected from three locations (SD01-SW01-121115, SD01-SW02-121115, and SD01-SW03-121115) and groundwater samples from the four piezometers (SD01-TP-01, SD01-TP-02, SD01-TP-03, and SD01-TP-04). All samples were analyzed for VOCs, VPH and total inorganics.

5.1.3 DEVIATIONS FROM WORK PLAN

With the exception of procedural deviations, work was conducted in accordance with the CSM Work Plan and the subsequent clarifications provided by MDEQ. The quality and overall results of the surface water investigation program were not impacted by the deviations, which are summarized as follows:

- The CSM Work Plan indicated that at each surface water sampling location, the water depth would be measured and recorded, as practicable. Additionally, samples would be analyzed in the field for pH, specific conductance, temperature, dissolved oxygen, and turbidity. During the February and March 2010 sample collection events, surface water had not accumulated to a point where a depth to water could be measured. In most instances, field personnel dug a hole within the channel of the drainage to allow accumulation of surface water sufficient to collect

a sample. Field parameters were not measured during these events due to the unavailability of water quality meters at the time of sampling. As such, equipment calibration forms are not available for these sampling events.

- During the July 20, 2010 inspection and surface water collection event, a water quality meter was present and available at the site. Target water quality parameters were recorded during the sampling event, with the exception of specific conductance. Specific conductance was not recorded for samples collected during this event, as the instrument would not calibrate within 10% of the known standard.
- Water quality parameters were not measured during the August 10, 2010 inspection/sampling event due to unavailability of a water quality meter at the site. As such, equipment calibration forms are not available for this sample event.
- During the September 9, 2010 inspection and surface water sampling event, standing water present in SD04 and SD07 was not sampled (as noted in Section 5.2.1, no water was present when staff returned to the locations after completing the site-wide inspection).
- Water quality parameters were not measured during the June 6, 2012 sampling event due to unavailability of a water quality meter at the site. As such, equipment calibration forms are not available for this sample event.

5.1.4 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. A compilation of the detailed results of the Tier III data validations are presented in Appendix 5-D. This section is further divided into two subsections, one addressing data validation results for initial investigation activities performed at all surface drainages at the Facility as part of the Phase II RI (March 2010 through June 2012), and the second to present data validation results for data generated by additional SD01 monitoring activities conducted after June 2012 and in relation to monitoring of the hydrocarbon-impacted groundwater seeps and associated surface water.

5.1.4.1 SAMPLING ACTIVITIES - MARCH 2010 TO JUNE 2012

A total of 65 samples consisting of 43 environmental samples, 5 blind duplicates, 2 equipment blanks, and 15 trip blanks, were collected between March 2010 and June 2012. This collection effort resulted in approximately 4,855 sample results including: 3,608 environmental sample results, 461 field duplicate sample results, 186 equipment blank sample results, and 600 trip blank sample results. The results were reported in 16 lab data packages that were reviewed and validated. The laboratory reports are included in Appendix 5-C and the individual data validation reports are included in Appendix 5-D.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 264 data points were qualified as J by the laboratory. Out of these laboratory J flags, 201 were preserved during Tier III DV.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	357
UJ	620
JB	12
R	10
TOTAL	999

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 5-D. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal requirements were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	15	34.9%	1 per cooler*
Equipment Blanks	2	4.6%	5%
Blind Duplicates	5	11.6%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 4,069 environmental and field duplicate sample results reported and validated between March 2010 and June 2012, 10 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the surface water sampling activities is 99.75%, which is greater than the required 90%.

5.1.4.2 SAMPLING ACTIVITIES (SD01 ONLY) – JULY 2012 – DECEMBER 2012

A total of 35 samples consisting of 26 environmental samples, 4 blind duplicates, and 5 trip blanks, were collected from SD01 during the period July 1, 2012 to December 31, 2012. This collection effort resulted in approximately

1,824 sample results including 1,409 environmental sample results, 215 blind duplicate sample results, and 200 trip blank sample results. The results were reported in five lab data packages that were reviewed and validated. The laboratory reports are included in Appendix 5-C and the individual data validation reports are included in Appendix 5-D.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 69 data points were qualified as J by the laboratory and 64 were preserved during Tier III data validations.

The following table summarizes the distribution of the applied data qualification flags.

Flag	Total
J	126
UJ	78
JB	1
R	1
TOTAL	206

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 5-D. Data qualification summary tables are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Quality control sample submittal requirements were met. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	5	19%	1 per cooler*
Blind Duplicates	4	15%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 1,624 environmental and field duplicate sample results reported and validated between July and December 2012, 1 sample result was rejected as a result of the data validation review. The completeness measure for the data generated for the surface water sampling activities is 99.94%, which is greater than the required 90%.

5.1.5 RESULTS

Surface water samples were collected from SD01, SD02, SD03, SD07, and SD08 at the locations shown on Figure 5.1-2. Samples were not collected from the other drainages due to absence of surface water during each inspection event. Sampling protocols are described in Sections 2.1.3.1 and 5.1.1. Field documentation for the surface water samples is presented in Appendix 5-A.

Samples collected were analyzed for the constituents on the Facility COI list for groundwater and surface water (Table 2.1-2). Analytical data are presented in Tables 5.1-1 through 5.1-4. Figure 5.1-2 and Table 5.1-5 summarize the analytical results for the surface water samples. Also included are the analytical results from the additional monitoring conducted in SD01, through end of 2012 (see Section 5.1.2). However, groundwater samples collected from the piezometers in SD01 are not included in the summary data compilation and statistics discussed in this section. Additional investigation activities in SD01, related to determination of potential source(s) of impacts to groundwater seeps, are discussed in Chapter 8.0. A comprehensive presentation of SD01 data collection activities will be submitted concurrently with the annual groundwater quality monitoring report, to be submitted to MDEQ in March 2014.

Data were evaluated utilizing the protocol described in Section 2.3.2. For surface water, results were compared to surface water standards in DEQ Circular-7. Note that for surface water, there are no standards for VPH, EPH, and resulting carbon fractions, and therefore, no comparisons of analytical results were made. For groundwater samples collected from piezometers installed in SD01, results were compared to groundwater standards in DEQ-7.

The results of the evaluation for surface water data collected through December 2012 from all drainages are presented below.

Note that CEMC has also collected surface water samples from SD01 for dissolved metals analysis, for purpose of evaluating total metals data and the effects that suspended sediment in turbid samples (reacting with nitric acid preservative in sample bottles) may have on analytical results. While dissolved metals data for surface water are not compared to applicable screening levels, those results are included in the data table (Table 5.1-1) for comparison to total metals results. The MDEQ standard for metals in surface water is based on total metals, while the standard for metals in groundwater is based on dissolved metals. Groundwater at the Facility is being sampled for dissolved metals analysis.

SD01 Evaluation, Surface Water

Constituents detected in surface water samples collected (between February 2010 and December 2012) from SD01 at a concentration exceeding the MDEQ standard consisted of the following (as shown below):

- Inorganics:
 - Antimony (total), 2 of 24 samples [8% of the samples]
 - Arsenic (total), 17 of 24 samples [71% of the samples]
 - Barium (total), 2 of 24 samples [8% of the samples]
 - Beryllium (total), 4 of 24 samples [16% of the samples]
 - Cadmium (total), 2 of 24 samples [8% of the samples]
 - Chromium (total), 3 of 24 samples [13% of the samples]
 - Cobalt (total), 17 of 24 samples [71% of the samples]
 - Copper (total), 0 of 24 samples [0% of the samples]
 - Lead (total), 7 of 24 samples [29% of the samples]
 - Mercury (total), 2 of 24 samples [8% of the samples]
 - Nickel (total), 8 of 24 samples [33% of the samples]
 - Selenium (total), 9 of 24 samples [38% of the samples]
 - Silver (total), 0 of 24 samples [0% of the samples]
 - Vanadium (total), 8 of 24 samples [33% of the samples]
 - Zinc (total), 0 of 24 samples [0% of the samples]
- VOCs:
 - Benzene, 7 of 38 samples [18% of the samples]
 - 1,2-Dichloroethane, 1 of 38 samples [3% of the samples]
- SVOCs:
 - Bis (2-ethylhexyl) phthalate, 1 of 20 samples [5% of the samples]

The locations at which one or more constituents exceeded the MDEQ standard for surface water in SD01 are indicated on Figure 5.1-2.

SD01 surface water data (inorganics) were also evaluated against the MDEQ-approved background data set described in Section 2.3.2. Note that the approved background value is greater than the MDEQ standard for the constituents

antimony, arsenic, barium, cadmium, cobalt, mercury, nickel, and selenium. Constituents detected in surface water samples collected (between February 2010 and December 2012) from SD01 at a concentration exceeding the MDEQ-approved background value consisted of the following (as shown below):

- Antimony (total), 2 of 24 samples [8% of the samples]
- Arsenic (total), 6 of 24 samples [25% of the samples]
- Barium (total), 5 of 24 samples [21% of the samples]
- Beryllium (total), 3 of 24 samples [13% of the samples]
- Cadmium (total), 0 of 24 samples [0% of the samples]
- Chromium (total), 6 of 24 samples [25% of the samples]
- Cobalt (total), 5 of 24 samples [21% of the samples]
- Copper (total), 2 of 24 samples [8% of the samples]
- Lead (total), 6 of 24 samples [25% of the samples]
- Mercury (total), 0 of 24 samples [0% of the samples]
- Nickel (total), 4 of 24 samples [25% of the samples]
- Selenium (total), 1 of 24 samples [4% of the samples]
- Silver (total), 0 of 24 samples [0% of the samples]
- Vanadium (total), 8 of 24 samples [33% of the samples]
- Zinc (total), 6 of 24 samples [25% of the samples]

SD01 Evaluation, Groundwater

Constituents detected in groundwater samples collected (between March 2012 and December 2012) from piezometers installed in groundwater seep areas within SD01 were compared to MDEQ groundwater standards. Constituents detected at a concentration exceeding the MDEQ standard consisted of the following (as shown below):

- Inorganics:
 - Cobalt (total), 4 of 9 samples [44% of the samples]
 - Nickel (total), 1 of 9 samples [11% of the samples]
 - Selenium (total), 6 of 9 samples [67% of the samples]

- VOCs:
 - Benzene, 9 of 25 samples [27% of the samples]
 - 1,2-Dichloroethane, 6 of 25 samples [24% of the samples]
- SVOCs: None

The locations at which one or more constituents exceeded the MDEQ standard for groundwater in SD01 are indicated on Figure 5.1-2.

SD02 Evaluation

Constituents detected in the surface water sample collected from SD02 at a concentration exceeding the MDEQ standard consisted of the following:

- Inorganics: None
- VOCs: None
- SVOCs: None

The location where surface water was sampled in SD02 is shown on Figure 5.1-2.

SD02 surface water data (inorganics) were also evaluated against the MDEQ-approved background data set described in Section 2.3.2. Note that the approved background value is greater than the MDEQ standard for the constituents antimony, arsenic, barium, cadmium, cobalt, mercury, nickel, and selenium. No inorganic constituents were detected in the surface water sample collected from SD02 at a concentration exceeding the MDEQ-approved background values.

SD03 Evaluation

Constituents detected in the surface water samples collected from SD03 at a concentration exceeding the MDEQ standard consisted of the following:

- Inorganics:
 - Arsenic (total), 1 of 2 samples [50% of the samples]
 - Cobalt (total), 1 of 2 samples [50% of the samples]

- VOCs: None
- SVOCs: None

The locations at which one or more constituents exceeded the MDEQ standard are indicated on Figure 5.1-2.

SD03 surface water data (inorganics) were also evaluated against the MDEQ-approved background data set described in Section 2.3.2. Note that the approved background value is greater than the MDEQ standard for the constituents antimony, arsenic, barium, cadmium, cobalt, mercury, nickel, and selenium. Constituents detected in surface water samples collected (between February 2010 and December 2012) from SD01 at a concentration exceeding the MDEQ-approved background value consisted of the following (as shown below):

- Barium (total), 1 of 2 samples [50% of the samples]
- Cobalt (total), 1 of 2 samples [50% of the samples]

SD04 Evaluation

No surface water was observed/no samples were collected in SD04 during the Phase II RI.

SD05 Evaluation

No surface water was observed/no samples were collected in SD05 during the Phase II RI.

SD06 Evaluation

No surface water was observed/no samples were collected in SD06 during the Phase II RI.

SD07 Evaluation

Constituents detected in the surface water sample collected from SD07 at a concentration exceeding the MDEQ standard consisted of the following:

- Inorganics:
 - Lead (total), 1 of 1 samples [100% of the samples]
- VOCs: None
- SVOCs: None

The location at which one or more constituents exceeded the MDEQ standard are indicated on Figure 5.1-2.

SD07 surface water data (inorganics) were also evaluated against the MDEQ-approved background data set described in Section 2.3.2. Note that the approved background value is greater than the MDEQ standard for the constituents antimony, arsenic, barium, cadmium, cobalt, mercury, nickel, and selenium. Constituents detected in one surface water sample collected (between February 2010 and December 2012) from SD01 at a concentration exceeding the MDEQ-approved background value consisted of the following: barium and lead.

SD08 Evaluation

Constituents detected in the surface water samples collected from SD08 at a concentration exceeding the MDEQ standard consisted of the following:

- Inorganics:
 - Arsenic (total), 1 of 2 samples [50% of the samples]
 - Barium (total), 1 of 2 samples [50% of the samples]
 - Beryllium (total), 1 of 2 samples [50% of the samples]
 - Cadmium (total), 1 of 2 samples [50% of the samples]
 - Chromium (total), 1 of 2 samples [50% of the samples]
 - Cobalt (total), 1 of 2 samples [50% of the samples]
 - Lead (total), 1 of 2 samples [50% of the samples]
 - Mercury (total), 1 of 2 samples [50% of the samples]
 - Nickel (total), 1 of 2 samples [50% of the samples]
 - Vanadium (total), 1 of 2 samples [50% of the samples]
- VOCs: None
- SVOCs: Benzo(b)fluoranthene, 1 of 2 samples [50% of the samples]

All of the maximum detections from SD08 are associated with the surface water sample collected from the furthest downstream sample (SD08-052111SW).

The locations at which one or more constituents exceeded the MDEQ standard are indicated on Figure 5.1-2.

SD08 surface water data (inorganics) were also evaluated against the MDEQ-approved background data set described in Section 2.3.2. Note that the approved background value is greater than the MDEQ standard for the constituents antimony, arsenic, barium, cadmium, cobalt, mercury, nickel, and selenium. Constituents detected in surface water samples collected from SD08 at a concentration exceeding the MDEQ-approved background value consisted of the following (as shown below):

- Arsenic (total), 1 of 2 samples [50% of the samples]
- Barium (total), 1 of 2 samples [50% of the samples]
- Beryllium (total), 1 of 2 samples [50% of the samples]
- Chromium (total), 1 of 2 samples [50% of the samples]
- Cobalt (total), 1 of 2 samples [50% of the samples]
- Copper (total), 1 of 2 samples [50% of the samples]
- Lead (total), 1 of 2 samples [50% of the samples]
- Nickel (total), 1 of 2 samples [50% of the samples]
- Vanadium (total), 1 of 2 samples [50% of the samples]
- Zinc (total), 1 of 2 samples [50% of the samples]

As noted above, all of the maximum detections from SD08 are associated with the surface water sample collected from the furthest downstream sample (SD08-052111SW).

5.2 SEDIMENT

The following sections discuss and present the results of activities conducted to investigate sediment conditions in the eight surface drainages associated with the Facility (Figure 5.1-1). As noted in the CSM Work Plan, and from observations made during inspection of the drainages and summarized in Section 2.1.1, sediments were not always present within a surface drainage or were present only as a thin veneer. Taking into account the absence or minimal presence of sediment, investigations were conducted in accordance with the procedures and methods described in the CSM Work Plan and Phase II RI Work Plan FSP, and summarized in Section 2.1.3 of this Report.

Sediment samples were analyzed for constituents on the Facility's COI list for soil and sediment (see discussion in Section 2.1.5 and Table 2.1-1). Samples were typically designated with a "SD" prefix and the surface drainage

number. No suffix was used, as opposed to the “SW” suffix used for surface water samples. Naming convention utilized during sediment investigations is presented in Table 2.1-3.

5.2.1 INVESTIGATION AND SAMPLING METHODS

Initial surface drainage inspections were conducted in February and March 2010, at which time the sediment screening and sampling activities described in the CSM Work Plan were completed. Surface sediment sampling locations were based on field conditions, with areas chosen down-gradient of possible seep or surface water tributaries as well as areas of greatest accumulation of sediment. As presented in Section 4.1 of the Phase II RI Work Plan, additional sediment investigations were planned based on data generated by the February and March 2010 sampling events, and as a contingency should additional seeps or areas with substantial sediment be discovered during the quarterly and monthly drainage inspections. Surface water was never observed in a number of the Facility surface drainages and ground conditions were dry during numerous inspections. In those cases, samples were field screened with an XRF unit and utilizing the in-situ screening methods described in Section 2.1.1 of this document.

Following is a summary listing of the sediment sampling events that were conducted during the course of the Phase II RI. Note that investigation activities have demonstrated true benthic sediment does not occur in the surface drainages associated with the Facility, with the exception of SD01. The term “sediment” is used in discussing these investigations to maintain consistency with the terminology used in the MDEQ May 16, 2008 SOW.

- SD01, SD02, and SD03 were inspected February 16-17, 2010. During the inspections, surface sediment samples were collected for laboratory analysis. A small allotment of each sediment sample was air dried and screened using an XRF unit. XRF screenings indicated lead was present in two of the three drainages, at one location in each of the two drainages; SD01 (SD1-03, 108 ppm lead) and SD02 (SD2-04, 32 ppm lead). Samples were submitted from these locations for laboratory analysis of the constituents on the soil COI list (Table 2.1-1).
- On March 3, 2010, all eight surface drainages were inspected. As sediment samples had previously been collected from SD01, SD02, and SD03, sediment screening and sampling was limited to SD04 through SD08. XRF field screenings for lead were non-detect at screening and sampling locations within SD05, SD07, and SD08. XRF screenings indicated lead was present in two of the five drainages, as follows:
 - SD04 (SD04-01 at 453 ppm lead). This sample location is directly north of the temporary soil stock pile and the former location of Tank Berm 13, and is near the location of the former lead blending plant.
 - SD06 (SD06-01 at 46 ppm lead). This location is approximately two-thirds of the downstream drainage distance between Tank Berms 18 and 25.

- As summarized in Section 5.1.1, seven of the eight surface drainages were inspected for surface water runoff on August 10, 2010. Surface water was present in two of the seven inspected drainages, SD01 and SD07. Suspended sediment was noted in the surface water runoff within SD07, and a sediment sample was collected from an area where sediment was being deposited. The XRF field screening result from the surface sediment deposit was non-detect for lead. A sample was submitted from this location for laboratory analysis of the constituents on the soil COI list (Table 2.1-1).
- On August 13, 2010, sediment step-out screening was conducted in SD04 in vicinity of a sample (SD04-01, collected March 3, 2010) with a reported analytical result for lead of 1,330 mg/kg, and consistent with the planned sampling identified in Section 4.1 of the Phase II RI Work Plan. Nineteen step-out screening locations (SD04-02 through SD04-20) were field screened for lead using a portable XRF unit. Surface water had never been observed in SD04. As noted above, XRF screening was conducted utilizing the in-situ screening procedures described in Section 2.1.1. Screening locations were spaced at approximately 50-foot intervals along the centerline of SD04. The XRF indicated the presence of lead above the instrument detection limit in 16 of the 19 screening locations. Ten of the 19 screening locations were upstream of sample location SD04-01. At two of the field screening locations (SD04-09 and SD04-17), the XRF indicated lead present at a concentration above 400 ppm (852 ppm and 1,201 ppm, respectively). Locations field screened are depicted on Figure 5.2-1. Samples were collected at four of the screening locations (SD04-07, SD04-11, SD04-13, and SD04-17) and submitted for laboratory analysis of the constituents on the Facility soil COI list (Table 2.1-1). It should be noted that many of the locations screened are within or immediately adjacent to the former process area, including the lead blending and ethyl plants (see Figure 1.2-3). The drainage itself is not well defined, consisting more of a vegetated swale and without a defined channel.
- On August 14, 2010, XRF readings were collected from eleven surface sediment screening locations (SD04-21 through SD04-31). These screening locations are located on the eastern extent of SD04 and extending into the engineered conveyance channel along the northern end of the Main Cell Landfill. Due to wet conditions, the screening samples were air-dried and screened with a portable XRF unit on August 18, 2010. The XRF indicated the presence of lead above the instrument detection limit in five of the eleven samples; the highest concentration was at location SD04-23 (273 ppm lead). On August 18, a laboratory sample was collected from SD04-23 and submitted for laboratory analysis.
- On August 27, 2010, step-out field screening was performed in SD01 in response to laboratory analytical results from the February 16, 2010 screening and sampling event. Twenty screening locations (SD01-05 through SD01-24) were field screened for lead using a portable XRF unit. Field screening locations were spaced at approximately 50 foot intervals along the drainage centerline and within the centerline of the main drainage side channels. Lead was detected at 4 of the 20 locations: SD01-11 (63 ppm lead), SD01-12 (62 ppm lead), SD01-13

(24 ppm lead), and SD01-14 (110 ppm lead). The detected lead locations are located between the upstream drainage culvert crossing (SD01-15) and the downstream manmade stock tank dam outlet (SD01-10). Samples were collected and submitted for laboratory analysis from screening locations SD01-14 (downstream of the drainage culvert) and SD01-21 (southern section of the drainage, near the confluence of the western and southern drainage branches).

As described in Section 2.3.1.2, a work plan proposing collection of samples for determination of background metals concentrations in surface water and sediment in Surface Drainage 01 and the unnamed lakebed was approved by MDEQ on February 13, 2013. Sediment samples for determination of background concentration were collected in late March 2013. Proposed background metals concentrations in surface water and sediment were presented in a September 23, 2013 submittal to MDEQ (*Technical Memorandum, Background and Data Gap Sampling Results and Background Evaluation, Metals Concentration in Sediment and Surface Water* [CEMC 2013d]). MDEQ approved the proposed background values in correspondence dated October 3, 2013. Further discussion of background determination for sediment is included in Chapter 8.0.

As noted previously in this section, true benthic sediment does not occur in the surface drainages associated with the Facility, with the exception of SD01. Sample results from SD01 are compared to background sediment values in the discussions following. Sample results from all other drainages are compared to the Facility's approved soil background values.

Sediment sample locations are shown on Figure 5.2-1. Analytical data are presented in Tables 5.2-1 through 5.2-4. Figure 5.2-1 and Table 5.2-5 summarize the analytical results for the sediment samples. Surface drainage inspection forms are included in Appendix 5-A. Laboratory reports and data validation reports are provided in Appendix 5-C and 5-D, respectively.

5.2.2 DEVIATIONS FROM WORK PLAN

With the exception of the following deviations, work was conducted in accordance with the CSM Work Plan and the subsequent clarifications provided by MDEQ. Deviations were as follows:

- The CSM Work Plan indicated that sediment samples would be collected with a stainless steel hand trowel or similar equipment and placed directly into laboratory-prepared sample containers. However, during the February 16-17, 2010 and March 3, 2010 sediment sample collection events in each of the eight drainages, the ground was frozen making it difficult to penetrate the ground surface with a hand trowel. In these instances, field personnel used a rock hammer to penetrate the ground surface. During the March 2010 sediment sampling event,

the samples to be analyzed for VOCs were placed directly into the sample containers; however, the samples for the remaining analyses were staged/composited in clean plastic zip lock bags while field personnel used a rock hammer to break chunks of the frozen sampled material into pieces small enough to fit into the containers and fill the voids.

- During the August 14, 2010 sediment sample collection at SD04, the sediment was saturated from the significant rainfall event (0.45 inches) that occurred between August 13 and August 14, 2010. The surface sediment was too wet to field screen with the XRF unit. In this instance, field personnel flagged each location and collected a small amount of sediment and allowed the soil air dry before field screening. Samples were collected on August 18, 2010 and submitted for laboratory analysis.

These deviations do not affect the overall results and conclusions from the sediment sampling effort.

5.2.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 5-D.

A total of 47 samples consisting of 25 environmental samples, 3 blind duplicates, 6 equipment blanks, and 12 trip blanks were collected between February 2010 and August 2010. This collection effort resulted in approximately 3,834 sample results including: 2,494 environmental sample results, 318 field duplicate sample results, 542 equipment blank sample results, and 480 trip blank sample results. The data were reported in 14 lab data packages that were reviewed and validated. The laboratory reports are included in Appendix 5-C and the individual data validation reports are included in Appendix 5-D. A compilation of the data validation results are presented in Appendix 5-E.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the data validation review, laboratory J flags were preserved in the data. A total of 126 data points were qualified as J by the laboratory. Out of these laboratory J flags, 102 were preserved during Tier III data validation.



The following table summarizes the distribution of applied data qualification flags.

<u>Flag</u>	<u>Total</u>
J	238
UJ	200
JB	24
R	69
TOTAL	531

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 5-D. Data qualification summaries are also included in each validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Analytical reports and electronic deliverables were complete. The frequency of quality control sample collection and analysis is summarized in the following table:

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	12	46.2%	1 per cooler*
Equipment Blanks	6	23.1%	5%
Blind Duplicates	3	11.5%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Of the 2,812 environmental and field duplicate sample results reported and validated between February 2010 and August 2010, 67 sample results were rejected as a result of the data validation review. The completeness measure for the data generated for the sediment sampling activities is 97.62%, which is greater than the QAPP required 90%.

5.2.4 RESULTS

In this section, results of the sampling program pertaining to sediments within surface drainages are presented. Sampling events for this program were conducted during the period of February through August 2010 and resulted in the collection of 28 sediment samples from the eight surface drainages. Those samples were analyzed for the full COI list constituents. Note that some sampling events discussed herein were conducted after submittal of both the CSM Update and the CSM Update Addendum; therefore, some analytical results for this program were not included in either of those reports.

CEMC personnel met with MDEQ representatives at the site field office on October 7, 2010 to identify step-out locations for additional soil sampling. During this meeting, CEMC personnel displayed field drafts of figures and tables summarizing soil investigation results current as of the date of the meeting, including results from sediment screening and sampling in surface drainages. Subsequent to that meeting, MDEQ requested via correspondence dated October 15, 2010 (Appendix 1-A) that CEMC submit a proposal for conducting additional sampling at the locations discussed during the October 7, 2010, which included step-out soil sampling for lead and EPH in SD04. CEMC submitted a proposal for conducting the additional sampling via correspondence dated November 5, 2010, which included step-out soil sampling in SD04.

The step-out sampling in SD04 has not been completed as of the date of this Report. The drainage is located well within Facility boundaries and adjacent to an excavated soil storage pile, currently active due to ongoing remedial interim actions. Additional sampling in SD04 is planned following completion of soil stockpiling activities associated with remediation of residential properties in town containing backfill soils taken from former tank berms at the refinery, as discussed further in Chapter 8.0.

Figure 5.2-1 shows the surface drainage areas and summarizes sediment data. The figure shows the locations at which samples were collected for laboratory analysis; color-coded symbols indicate whether the concentrations of inorganic constituents, VOCs/VPH fractions, and/or SVOC/EPH fractions exceeded a screening level (direct contact). In addition, Figure 5.2-1 summarizes the results of the field XRF screening for lead; color-coded symbols indicate whether the field XRF results exceeded the screening level of 400 ppm.

Data Evaluation

Section 2.3.1 describes the data evaluation approach in detail. Exceedances of the site-specific background values for inorganic constituents are listed in the sediment summary data table, Table 5.2-5. Note that sediment data from SD01 have been compared to the MDEQ-approved background sediment values for this drainage. Sediment data from all other surface drainages (SD02 through SD08) have been compared to the MDEQ-approved background soil values for the Facility. However, the data summary map focuses on the direct contact screening level exceedances.

Sediment Results

Figure 5.2-1 and Tables 5.2-1 through 5.2-5 summarize the analytical results for the sediment samples. Laboratory analytical reports for the sediment samples are provided in Appendix 5-C.

Sediment samples from 25 locations were collected from the eight drainages. Sediment samples were analyzed for the full COI List (Table 2.1-1) including VPH and EPH hydrocarbon fractions, VOCs, SVOCs, and inorganic constituents.

Field documentation, laboratory reports, and data validation reports for the sediment samples are provided in Appendices 5-A, 5-C, and 5-D, respectively.

Direct Contact Screening Evaluation

Constituents in the surface drainage sediment samples exceeding the direct contact SLs consisted of the following:

- Inorganics:
 - Arsenic (25 of the 25 samples [100% of the samples])
 - Cobalt (25 of the 25 samples [100% of the samples])
 - Lead (2 of the 25 samples [8% of the samples])
 - Vanadium (23 of the 25 samples [92% of the samples])
- VOCs: None
- SVOCs: None
- Carbon Fractions: None

The locations at which one or more constituents exceeded the direct contact SL are indicated on Figure 5.2-1.

As noted above, arsenic and cobalt were detected at a concentration above the direct contact SLs in all 28 samples collected, and vanadium was detected at a concentration above the direct contact SL in 26 of the 28 samples collected. However, the site-specific background values in surface soil calculated for these metals are above the screening levels.

Background concentrations of inorganic constituents were approved in MDEQ's June 12, 2013 correspondence, which is provided in Appendix 2-D, as well as on the Facility soil COI list (Table 2.1-1) and in the soil data summary tables that accompany Chapter 3.0.

Constituents detected in sediment samples collected from SD01 at a concentration exceeding the MDEQ-approved background value consisted of the following (as shown below):

- Antimony, 1 of 6 samples [17% of the samples]
- Barium, 3 of 6 samples [50% of the samples]
- Beryllium, 3 of 6 samples [50% of the samples]
- Chromium, 1 of 6 samples [17% of the samples]

- Lead, 3 of 6 samples [50% of the samples]
- Selenium, 3 of 6 samples [50% of the samples]
- Vanadium, 2 of 6 samples [33% of the samples]
- Zinc, 1 of 6 samples [17% of the samples]

Comparison of sediment samples results from the other surface drainages (SD02 through SD08) to the MDEQ-approved background soil values for the Facility show the following exceedances:

- Antimony, 7 of 19 samples [37% of the samples]
- Beryllium, 12 of 19 samples [63% of the samples]
- Chromium, 3 of 19 samples [16% of the samples]
- Colbalt, 1 of 19 samples [5% of the samples]
- Copper, 1 of 19 samples [5% of the samples]
- Lead, 10 of 19 samples [53% of the samples]
- Selenium, 5 of 19 samples [26% of the samples]
- Silver, 3 of 19 samples [16% of the samples]
- Vanadium, 9 of 19 samples [47% of the samples]
- Zinc, 4 of 19 samples [21% of the samples]

Table 5.2-5 presents summarized comparison data for the sediment samples.

Other than the metals discussed above, no constituents were detected at concentrations above the respective MDEQ surface soil RBSL in any of the sediment samples. Benzene, toluene, xylenes, anthracene, benzo(a)pyrene and dibenz(a,h) anthracene were identified in one or more samples at (estimated) concentrations below the respective practical quantitation limit (PQL). One or more of the three EPH fractions were detected at concentrations below the respective MDEQ surface soil RBSL in sediment samples from SD04, SD07, and SD08, respectively (see Figure 5.2-1). A forthcoming ecological risk assessment for the Facility will evaluate exposure for ecological receptors using the EPA Region 3 BTAG screening levels.

5.3 SOUTHEAST DRAINAGE/DIVERSION DITCH

During 2012, visual inspections and elevation surveys were performed on a man-made drainage/water conveyance ditch that terminates in SD08, near the southeast corner of the Facility. These activities were conducted in response to concerns that this drainage served as a diversion ditch carrying surface water runoff from SD08 southward. This ditch and the results of the inspections and surveys are discussed in more detail herein. The location of the diversion ditch is shown on Figure 5.3-1.

During 2009, CEMC was informed of a discussion between MDEQ representatives and the residents south of the Facility, who were concerned that a drainage ditch traversing their property may have been impacted by former refinery activities. The residents purportedly had been informed by a third party that the ditch was utilized to transport hydrocarbon waste during refinery operations and that their property was likely impacted.

Reviews of aerial photos suggested the presence of a ditch located southeast of Tank Berm 27, just outside of the original footprint of the former refinery. The ditch appeared to run in a generally southerly direction, crossing SD02 near its downstream termination point, through the residence near the main residence, then turning westward before terminating in another large drainage south of SD02.

Phase II RI activities conducted up to this timeframe, including surface water and sediment investigations in SD02, indicated there were no refinery impacts in this area. Efforts were made to gather additional information from the residents and third party fostering the claim that the ditch was utilized to transport former refinery waste, in order to assess the residents' concerns. However, no substantiated information or evidence was provided.

During 2012, CEMC surveyed the surface elevation along the diversion ditch. Elevations were recorded in the areas traversed by the ditch, both north and south of the residents' home. Recorded elevations are depicted on Figure 5.-1. As can be seen on the figure, the recorded elevations do not support a flow from the former refinery, as claimed. To the contrary, flows in the diversion ditch would be south to north, toward the former refinery property. As such, no further investigations are planned for this area.

5.4 UNNAMED INTERMITTENT LAKE

As discussed in Section 2.3.1.2, the need for collection of background samples to support the ERA portion of the upcoming RAA for the Facility was discussed during a meeting with MDEQ on May 31, 2012. It was agreed during the meeting that, as part of this effort, background samples would be collected from select surface water and sediment

locations within the unnamed intermittent lake located east of the former refinery. Investigation and sampling efforts related to data collection for determination of background concentrations are discussed in Section 8.3.

6.0 ADDITIONAL MEDIA

This chapter presents the results of investigation activities related to “additional media” requiring investigation as described in the May 16, 2008 SOW for the Phase II RI from MDEQ, and addressed during activities conducted in accordance with the CSM Work Plan, the Phase II RI Work Plan, or other work plans (for example, the Supplemental Investigation Work Plan as related to investigation of potential vapor intrusion) developed separately and at the request of MDEQ. This chapter also presents the results of several area investigations not identified in the May 16, 2008 SOW. These additional areas were investigated at the request of MDEQ in conjunction with preparation and finalization of the Phase II RI Work Plan.

6.1 RESIDENTIAL BASEMENT SUMPS

The original request to identify all residences with basements and investigate basement sumps within the known area of refinery-related soil and groundwater impacts was a component of MDEQ’s May 16, 2008 SOW for the Phase II RI Work Plan, and subsequent comment letter (May 26, 2009) on the draft Phase II RI Work Plan. The request for a residential sump investigation was based on the potential for contaminated groundwater to enter basement sumps, serving as a contaminant pathway and potentially impacting indoor air within a residence. Therefore, the residential sump sampling program focused on those residences with basements within the known area of impacts, as had been defined when determining the focus area for the requested VI investigations (see summary of prior investigation in Section 1.4, and detailed discussion of VI investigations in Section 6.2).

Both the May 2008 SOW and the May 2009 comment letter were issued prior to completion of the report summarizing results from the VI investigation completed in March 2009 (*Supplemental Investigation Pathway Evaluation and March 2009 Additional Vapor Intrusion Investigation Results* [CEMC 2009d]). Via correspondence dated October 13, 2009, MDEQ required CEMC to perform a follow-up investigation in early 2010 at thirty of the residences included in the March 2009 investigation (see discussion in Section 6.2.7 of this Report). At those residences, one or more petroleum related constituent was measured in indoor air above the respective MDEQ indoor air screening level. Locations where there were no exceedances of the indoor air screening criteria were not included in the resampling effort.

The additional VI investigation was performed during January/February 2010. Of the thirty residences sampled, five were identified as having basements with sumps and, therefore, comprised the residential sump investigation as outlined in Section 4.2 of the Phase II RI Work Plan.

Investigation methods and results, the later inclusion of a sixth residence in the sump sampling program, and the later resampling of one of the original five residences are discussed in the following sections.

6.1.1 INVESTIGATION METHODS

The five residences (identified as SI30, SI39, SI42, SI44, and SI46) identified as having basements with sumps were sampled in August and September 2010. As outlined in Section 4.2 of the Phase II RI Work Plan, investigation methods involved the collection of a water sample from identified sumps, during a high groundwater table period when sumps were most likely to contain water. Sampling dates and times were coordinated with residents to ensure a sufficient sample volume was present in the sump. In some cases, residents were asked to unplug the sump pumps one day prior to sampling in order to allow a sufficient volume of water to accumulate in the sump. Additionally, a preferred order for filling sample bottles was established, similar to that discussed in Section 4.3.3, in the event the volume of sump water was insufficient to fill the full suite of laboratory bottles.

Prior to sample collection, water quality parameters (pH, temperature, specific conductance, salinity, total dissolved solids, dissolved oxygen, oxidation/reduction potential, and turbidity) were measured using a calibrated water quality meter and recorded. If more than one sump was present in a basement, separate samples were collected from each sump. Basements were photographed and a sketch of the basement, including dimensions, general layout, and sump location, were recorded on field forms, along with an assessment of the sump water quality (e.g., noticeable odors, color of sump water, condition of pump, etc.). Grab samples were collected utilizing surface water sampling methods described in Section 2.1.3 of this Report.

Samples were submitted for laboratory analysis of the constituents on the Facility COI list for groundwater and surface water (Table 2.1-2). Naming convention used for samples collected during the residential sump investigation were a continuation of that used to identify residences during the prior VI investigations, i.e., an “SI” prefix with sequential numbering for each residence (see Table 2.1-3). Field forms generated during this investigation are presented in Appendix 6-A and equipment calibration forms are presented in Appendix 6-B. Analytical results are discussed in Section 6.1.4.

In March 2011, the sump at a sixth residence was sampled at the request of the property owner, who had contacted MDEQ with concerns about surface water runoff from the Facility and potential impact to water in their basement sump. Sample collection methods and laboratory analyses performed were the same as those utilized during the 2010 sump investigation. This property is located well outside of the area of known groundwater impacts, as defined for VI investigations and, therefore, does not contain the “SI” prefix assigned to properties included in the VI investigations.

The property location ID and sample naming convention for this sump sample (H2P1) was instead determined based on the Town of Sunburst block grid utilized during the residential soil investigation (Section 3.10).

Below is a summary list of the six properties included in the residential sump investigation. For ease of identification, the original five properties with “SI” prefixes have been assigned IDs corresponding to the Town of Sunburst block grid, which is depicted on Figure 3.10-1.

Location ID	Block Grid ID	Construction Type	Sump Description / Location
SI30	U-V/5-6	House, full basement	Two sumps present; ~1.5' x ~3' rectangular sump with pump in southeast corner of basement. ~3' dia. sump w/o pump in northern half of basement.
SI39	Q5P3	House, full basement	~16" dia. sump with pump in northeast corner of basement.
SI42	R5P1	House, slab on grade partial basement with dirt floor	~2' x ~3' hole with bucket and sump pump in northern portion of basement.
SI44	M3P4	House, full basement	~18" dia. uncovered sump in northeast corner of basement.
SI46	Q5P2	House, basement with dirt floor (3/4 of home), crawlspace (1/4 of home)	Sump located in northeast corner of basement laundry room.
N/A	H2P1	House, basement with concrete floor. Basement used for storage.	Sump located in northwest corner of basement, in room separate from main basement; consists of plastic 55-gallon drum.

In June 2011, an additional sump sampling event was conducted at property SI39 (Q5P3). Following an absence of several days during which rainfall occurred, the property owner(s) found the basement sump’s pump had failed, resulting in water pooling in the basement. The property owner(s) contacted MDEQ and reported that “hydrocarbon” was entering their basement sump. CEMC sampled the water in the sump the day after the incident was reported to MDEQ. At the time of the second sampling event, the sump pump was operational and much of the pooled water had been removed from the basement, with a few areas remaining damp or containing standing groundwater.



Prior to sampling, CEMC and MDEQ representatives inspected the sump. An immiscible fluid was noted floating on the sump water and a slight odor was present. A PID was used to screen the air above the sump water for VOCs. No readings above 1.0 ppm were recorded by the PID.

A grab water sample was collected from the sump and submitted for analysis of the constituents on the Facility groundwater and surface water COI list. A sample of the immiscible fluid also was collected and submitted to Newfields Laboratory for forensic analysis. Newfields Laboratory's analytical report indicated the immiscible fluid sampled was comprised of a low viscosity lubricating oil, similar to that utilized in pumps, and likely emanating from the pump within the SI39 basement sump. The Newfields report is presented in Appendix 6-C. The analytical results for the water sample collected from the sump are discussed in Section 6.1.4

6.1.2 DEVIATIONS FROM WORK PLAN

The second sump sampling event conducted at SI39 included collection of a sample for forensic analysis, which was not a component of the Phase II RI Work Plan. The decision to collect the additional sample was based on the report made to MDEQ and observed conditions during the sampling event. There were no other deviations from the Work Plan during residential sump investigation activities.

6.1.3 DATA VALIDATION

As discussed in Section 2.2, Tier III data validations were performed on data generated during the Phase II RI. This section summarizes the overall distribution of data qualification flags. Detailed results of the Tier III data validations are presented in Appendix 6-E.

A total of 18 samples consisting of 11 environmental samples, 1 blind duplicate, 1 equipment blank, and 5 trip blanks, were collected between August 2010 and June 2011. This collection effort resulted in approximately 1,887 sample results including: 857 environmental sample results, 108 field duplicate sample results, 93 equipment blank sample results, and 200 trip blank sample results. The results were reported in 4 lab data packages that were reviewed and validated. The laboratory reports are included in Appendix 6-D, and the individual data validation reports are included in Appendix 6-E. A compilation of the data validation reports are presented in Appendix 6-F.

Data were qualified with J flags by the laboratory if the result was greater than or equal to the MDL but less than the RL. Unless qualified for other reasons in the validation review, laboratory J flags were preserved in the data. A total of 30 data points were qualified as J by the laboratory. Out of these laboratory J flags, 23 were preserved during the Tier III data validations.

Flag	Total
J	35
UJ	54
JB	2
R	1
TOTAL	92

Data qualifiers applied to this data set are discussed in the detailed description of data validation procedures, presented in Appendix 2-B, and in the individual data validation reports in Appendix 6-E. Data qualification summaries are also included in each data validation report as Attachment B.

The reported analytical methods were in compliance with the QAPP. Analytical reports and electronic deliverables were complete. The frequency of quality control sample collection and analysis is summarized in the following table.

Sample	QC Samples Collected	QC Sample Frequency	Frequency Requirement
Trip Blanks	5	45.45%	1 per cooler*
Equipment Blanks	1	9.09%	5%
Blind Duplicates	1	9.09%	10%

*Trip blanks are required for each cooler containing samples for volatiles analysis by SW846 8260B and/or MA-VPH, which was met.

Quality control sample submittal met the requirements with the exception of blind duplicates that were not collected at the required frequency. However, these samples are part of a larger project in which field duplicate adequacy was met. Laboratory quality control samples were also analyzed at the required frequencies.

Of the 965 environmental and field duplicate sample results reported and validated between August 2010 and June 2011, 1 sample result was rejected as a result of the data validation review. The completeness measure for the data generated for the residential sump sampling activities is 99.9%, which is greater than the required 90%.

6.1.4 RESULTS

As stated above, water samples collected from residential sumps were submitted for laboratory analysis of the constituents on the Facility COI list for groundwater and surface water (Table 2.1-2). Residential sump data were evaluated using the methods described in Section 2.3.2. Analytical results were screened against MDEQ standards for groundwater, as directed by MDEQ in their correspondence dated May 26, 2009 and May 14, 2010 (see Appendix 1-A). Analytical results, presented in Tables 6.1-1 through 6.1-4, are summarized as follows:

Inorganics - Of the metals on the Facility's COI list, lead is the constituent of primary concern. No samples exceeded MDEQ lead standards. There were 2 metals that did exceed MDEQ standards.

- Antimony – 1 exceedance from 1 sump (SI39) at a reported concentration of 0.0149 mg/L.
- Selenium – 5 exceedances from 4 sumps; 3 exceedances were from the same sump (SI39, samples from two separate events and including one blind duplicate). The highest reported concentration was 0.372 mg/L.

VOCs – No VOCs exceeded MDEQ standards in any of the residential sump samples.

SVOCs – Of the 37 SVOCs analyzed, 2 exceeded MDEQ standards.

- Bis(2-Ethylhexyl)phthalate – 1 exceedance from 1 sump, at a reported concentration of 0.018 mg/L.
- 1-Methylnaphthalene – 1 exceedance from 1 sump, at a reported concentration of 0.0021 mg/L.

Both exceedances occurred in the sump sample collected from SI39 in June 2011.

VPH-EPH – Of the 8 VPH-EPH fractions/total hydrocarbons analyzed, 4 exceeded MDEQ standards.

- TEH – 2 exceedances from 2 sumps. The highest reported concentration was 170 mg/L from SI39. The second exceedance was 1.6 mg/L (results with a “J” flag) from SI30.
- C9-C18 Aliphatic – 1 exceedance from 1 sump; SI39 at a reported concentration of 54 mg/L (results with a “J” flag).
- C11-C22 Aromatic - 1 exceedance from 1 sump; SI39 at a reported concentration of 11 mg/L.
- C19-C36 Aliphatic – 1 exceedance from 1 sump; SI39 at a reported concentration of 100 mg/L (results with a “J” flag).

With a few exceptions, the exceedances summarized above are associated with the water sample collected from the SI39 sump in June 2011. Furthermore, all the exceedances at SI39 occurred in the sump water sample collected during June 2011. As discussed in Section 6.1, the circumstances leading to that sampling event involved the failure of a sump pump, resulting in water pooling in the basement and likely contacting a number of materials, including lubricating oil from the failed pump. This is supported by the report from Newfields Laboratory (Appendix 6-C) and appears to be further supported by the SVOC and VPH-EPH data summarized above.

The exceptions involve the exceedances associated with inorganics and TEH. There are no clear patterns associated with some of the inorganics detected during Phase II RI investigations, including antimony and selenium. Neither constituent has been considered a primary concern at the Facility. Selenium is a common element of soils, and both antimony and selenium have been regularly detected in groundwater, including that which is considered unimpacted (see Tables 4.6-5A through 4.6-9A) by the former refinery. The exceedances of MDEQ standards for these two constituents do not appear to reflect impacts resulting from the former refinery. The second TEH exceedance, from the second sump at SI30, was only slightly above the MDEQ standard and there were no carbon fractions that exceeded their corresponding MDEQ standards. The only other exceedance from that same sump was selenium.

The overall conclusion from the results summarized above is that groundwater impacted by the Facility is not entering residential basement sumps.

6.2 VAPOR INTRUSION INVESTIGATION

MDEQ required, in correspondence dated December 13, 2004, that CEMC perform additional investigative and assessment activities at the Facility. Specifically, MDEQ required that CEMC complete supplemental investigative work to determine the following:

1. The relationship of indoor air VPH concentrations to the VPH concentrations found in the residual soil and groundwater plume
2. The nature and extent to which VPH are present in indoor air as a result of vapor intrusion from the residual soil and groundwater plume that extends beneath some of the residences in the Town of Sunburst
3. The risk from exposure to the VPH concentrations found in indoor air as a result of soil and groundwater contamination

Since Montana did not have State-specific guidance for assessing vapor intrusion during the course of this investigation, the *OSWER Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils* (USEPA 2002b) as well as other state and industry guidance (DTSC 2005, ITRC 2007, NJDEP 2005) were used by CEMC to develop the sampling program and to evaluate the data to determine appropriate action. As directed by MDEQ in the approved version of Addendum No. 2 (originally submitted August 31, 2008, revised November 13, 2008), to the *Revised Supplemental Investigation Work Plan* (“Revised SI Work Plan”, CEMC 2006a) “when selecting indoor air screening values for compounds of concern, MDEQ requires either the USEPA VI Guidance generic screening values (Table 2B of that guidance) or site-specific screening values based on background that are calculated using the 95th percentile Upper Confidence Limit (UCL).” Additionally, MDEQ approved indoor air

screening criteria for benzene and 1,3-butadiene ($1.46 \mu\text{g}/\text{m}^3$ and $0.44 \mu\text{g}/\text{m}^3$, respectively) as part of Addendum No. 2. These values were developed to account for potential background issues and in the case of 1,3-butadiene to account for the impracticality of reporting results at or below the USEPA screening criteria.

MDEQ provided revised screening values in a letter dated August 28, 2008. Screening criteria were updated again by MDEQ and provided to CEMC in correspondence dated June 22, 2009. MDEQ directed CEMC to use the USEPA Regional Screening Levels (USEPA 2009) for those chemicals that screening values were not provided. These screening criteria are provided in Table 6.2-1.

6.2.1 SUPPLEMENTAL INVESTIGATION WORK PLAN DEVELOPMENT

CEMC submitted the Supplemental Investigation Work Plan (CEMC 2005b) on June 24, 2005 to address MDEQ's request for further evaluation of the vapor intrusion pathway. MDEQ reviewed that document and provided comments in correspondence dated November 3, 2005. CEMC subsequently submitted a Revised SI Work Plan on November 22, 2005, as required by MDEQ. MDEQ reviewed that document and provided comments in correspondence dated February 2, 2006. CEMC completed additional revisions to the document (submitted February 17, 2006), and submitted a final version of the document (CEMC 2006a) on April 10, 2006 (in response to March 24, 2006 comments from MDEQ). The April 10, 2006 document was subsequently approved by MDEQ. The following subsections discuss the Revised SI Work Plan and subsequent addendums.

6.2.2 REVISED SI WORK PLAN AND ADDENDUM (PHASE I)

The Revised SI Work Plan addressed the installation and sampling of deeper (i.e., greater than 5 ft-bgs) multi-level soil gas wells located in close proximity to existing groundwater monitoring wells both within and outside of the area of the shallow groundwater plume ("the plume") associated with the 1955 gasoline pipeline release. The Revised SI Work Plan also addressed the collection of groundwater data to evaluate whether measured soil gas concentrations were consistent with dissolved phase constituent concentrations. Due to uncertainty regarding the use of data derived from the multi-level soil gas samples, CEMC and MDEQ agreed to develop the final version of the Revised SI Work Plan in two phases, with the April 10, 2006 document serving as the first of those two phases. On April 13, 2006, CEMC received approval of the Revised SI Work Plan from MDEQ.

6.2.3 ADDENDUM NO. 1 TO THE REVISED SI WORK PLAN (PHASE II)

On April 17, 2006, CEMC submitted the first proposed addendum to the Revised SI Work Plan (CEMC 2006b), addressing the use of data derived from the multi-level soil gas wells, the installation of near slab soil gas monitoring wells within two meters horizontally of structures (both within and outside of the plume), and the proposed change of

location of one multi-level soil gas well (SIVW5). MDEQ expressed concern over the applicability of the multi-level soil gas wells on determining pathway completeness for individual structures since these wells were not located adjacent to occupied structures. CEMC agreed to install near slab wells to provide data for each of the structures that were located above the extent of the shallow groundwater plume to address these concerns. Near slab wells were also installed at several structures that did not overlie the extent of the shallow groundwater plume to provide data for evaluating background conditions. On April 24, 2006, CEMC received approval of the first addendum to the Revised SI Work Plan from MDEQ.

CEMC conducted the first stage of soil gas well installation and sampling during seasonal low groundwater conditions in late April/early May 2006, which included the installation and sampling of five multi-level soil gas monitoring wells (SIVW1 – SIVW5), and 23 near slab soil gas monitoring wells (SI 01 – SI 23). Monitoring locations are presented on Figure 6.2-1.

6.2.4 ADDENDUM NO. 2 TO THE REVISED SI WORK PLAN (PHASE II)

On August 31, 2006, CEMC submitted Addendum No. 2 to the Revised SI Work Plan to MDEQ (CEMC 2006c). The modifications/additional investigation addressed in this addendum to the Revised SI Work Plan included:

- Installation of near slab soil gas wells at additional residences. Capillary fringe near slab soil gas wells were proposed at the four residences located within the plume where installation of a soil gas well was unsuccessful during the April/May 2006 field activities due to access difficulties for the drill rig. Hand-augers were used to install the near slab wells within two meters of the residence foundations.
- Further evaluation of the vapor intrusion pathway at selected residences. CEMC proposed to further evaluate the vapor intrusion pathway at two residences located over the plume (SI 02 and SI 05) including simultaneous collection of soil gas, crawlspace, indoor air, and outdoor air samples. This additional investigation was proposed because the May 2006 soil gas sampling results were reported above the Office of Solid Waste and Emergency Response (OSWER) Draft VI Guidance generic screening values (assuming an attenuation factor of 0.002) for one or more petroleum related constituents. MDEQ's April 2011 VI Guidance (MDEQ 2011) does not allow for the application of generic attenuation factors to soil gas sample results. Rather, MDEQ relies upon a multiple lines of evidence approach and empirical data collection to determine the risk of vapor intrusion to indoor air. However, the Facility's VI investigation was conducted prior to issuance of the April 2011 VI Guidance.
- Additional soil investigation at selected residences. CEMC also proposed to further investigate the nature, degree, and extent of shallow soil contamination present at the two residences mentioned above, which are located over the shallow groundwater contaminant plume (SI 02 and SI 05).

On September 11, 2006, CEMC received comments from MDEQ on Addendum No. 2. CEMC submitted revisions to the document on November 13, 2006, which MDEQ approved on November 17, 2006. Work was conducted in September 2006 for the installation of the four near slab soil gas wells (SI 24 – SI 27). However, a near slab well could not be installed at SI 27 due to shallow groundwater (i.e., at depths less than 4 ft-bgs).

In September and October 2006, a second round of soil vapor monitoring, representative of high groundwater conditions, was completed within near slab wells at those residences sampled in May 2006 and at the three residences where near slab soil gas wells were successfully installed in September 2006. Soil gas samples were also collected from the five multi-level soil gas monitoring wells (SIVW1 – SIVW5).

Further evaluation of the vapor intrusion pathway was completed at SI 02 and SI 05 in January 2007, and included the collection of indoor air, crawlspace, and outdoor air samples. Additionally, indoor air, crawlspace, and outdoor air samples were collected at SI 27, in lieu of collecting near slab soil gas samples.

An investigation of the nature, degree, and extent of shallow soil contamination present at two residences (SI 02 and SI 05) was also conducted between January and late March 2007. Activities included the installation of 17 soil borings (SI 01 – SI 17).

6.2.5 ADDENDUM NO. 3 TO THE REVISED SI WORK PLAN (PHASE II)

On April 18, 2008, CEMC submitted Addendum No. 3 to the Revised SI Work Plan to MDEQ (CEMC 2008c). Addendum No. 3 included the following:

- Installation of near slab soil gas monitoring wells, soil boring, and groundwater monitoring well at SI 28 and further evaluation of the vapor intrusion pathway. CEMC proposed to install a capillary fringe near slab soil gas well and a groundwater monitoring well at SI 28. As a conservative measure, CEMC also proposed collection of indoor air, sub-slab, garage, and outdoor air samples at SI 28.
- Installation of multi-level soil gas wells at selected locations. CEMC proposed to install two multi-level soil gas wells (SIVW6 and SIVW7) on undeveloped property (located north of the Grace Gospel Church) located within the limits of the groundwater plume.
- Further evaluation of the vapor intrusion pathway at selected locations. CEMC proposed to further evaluate six locations (SI 02, SI 03, SI 04, SI 05, SI 11, and SI 14) for completeness of the vapor intrusion pathway. Work performed included installation of sub-slab monitoring probes (at residences where there was not a crawlspace) and collection of near slab, sub-slab, crawlspace, indoor air, garage air (if attached garage was present at residence),

and outdoor air samples. This additional investigation was conducted based on the May, September, or October 2006 soil gas sampling results which indicated an exceedance of the OSWER Draft VI Guidance generic screening values (assuming an attenuation factor of 0.02) for one or more petroleum related constituents. MDEQ's April 2011 VI Guidance (MDEQ 2011) does not allow for the application of generic attenuation factors to soil gas sample results. Rather, MDEQ relies upon a multiple lines of evidence approach and empirical data collection to determine the risk of vapor intrusion to indoor air. However, the Facility's VI investigation was conducted prior to issuance of the April 2011 VI Guidance.

Additionally, soil vapor samples were collected at SI 25 and SI 26, and indoor air/crawlspace samples were collected at SI 27 to meet the requirement that samples be collected during periods of both high and low groundwater conditions, as required by MDEQ. CEMC acknowledges that MDEQ does not currently support the use of generic attenuation factors.

CEMC received approval to complete the proposed work in a letter from MDEQ dated April 23, 2008. CEMC completed investigation activities associated with Addendum No. 3 during May 2008, during low groundwater conditions.

Based on the results of the May 2008 sampling, additional indoor air, sub-slab, garage air and outdoor air sampling was completed at SI 03 and SI 28 during July and August 2008. Additionally, LNAPL was detected in an observation well during November 2006 supplemental pilot testing of multi-phase extraction technology at the property located adjacent to SI 10. Therefore, as a conservative measure, further investigation of the vapor intrusion pathway was completed at SI 10, including the collection of indoor air, sub-slab, and outdoor air samples.

6.2.6 ADDITIONAL VI SAMPLING AND ANALYSIS PLAN

In a letter dated December 22, 2008, MDEQ required CEMC to collect paired indoor air and sub-slab and/or crawlspace samples to evaluate the VI pathway based on their concern regarding the applicability of the previous data collection efforts for evaluating pathway completeness at individual structures. On March 5, 2009, CEMC submitted the Additional VI Sampling and Analysis Plan (Additional VI SAP) (CEMC 2009a) proposing additional investigation activities which included:

- Expansion of the investigation area. MDEQ required CEMC to expand on the initial investigation area by approximately 150 feet beyond the extent of the groundwater plume. The expanded investigation area included locations SI 01, SI 03, SI 04, SI 06 through SI 10, SI 12 through SI 14, SI 23 through SI 42, SI 44 through SI 47, SI 49, and SI 50.

- Evaluation of VI pathway at each location. CEMC proposed to evaluate each location, situated within the expanded study area, for completeness of the VI pathway. Work performed included installation of sub-slab monitoring probes and collection of near slab, sub-slab and/or crawlspace, indoor air, garage air (if attached garage was present at residence), and outdoor air samples. Soil gas samples were also collected beneath the dirt crawlspace where there was adequate space available for probe installation and shallow water was not encountered. These “deep” soil gas probes were installed at four locations (SI 09, SI 23, SI 32, and SI 34) to approximately 5 ft-bgs.

6.2.7 CONFIRMATION RESAMPLING (JANUARY/FEBRUARY 2010)

In a letter dated October 13, 2009, MDEQ required CEMC to resample select locations included in the March 2009 expanded investigation to provide additional data for evaluating temporal variability and to provide additional data for evaluating the VI pathway at each of the selected locations. At each of the selected locations, one or more petroleum related constituents were measured above the respective MDEQ indoor air screening level. These locations were identified for resampling irrespective of the source of petroleum related constituents within the indoor air. Locations with no exceedances of the indoor air screening criteria were not included in the resampling effort. Additionally, at one location (SI 03), MDEQ required the installation of a mitigation system based on “the unacceptable risk posed by exposure to the concentrations of C₅-C₈ aliphatic hydrocarbons that were detected in the sub-slab and in the indoor air.” As such, this home was not included in the resampling event and a mitigation system was installed in June 2009, as discussed in Section 6.2.10. The sampling was completed in accordance with the MDEQ-approved Additional VI SAP (CEMC 2009a). Resampling activities were performed during January/February 2010 at 30 locations, including SI 01, SI 04, SI 07 through SI 10, SI 12, SI 13, SI 23 through SI 25, SI 28 through SI 33, SI 35 through SI 40, SI 42, SI 44 through SI 47, SI 49, and SI 50. Similar to the March 2009 event, sampling activities included installation of sub-slab and “deep” soil gas probes in crawlspaces at SI 23, SI 32, and SI 35, and collection of soil vapor from these probes. Additionally, crawlspace air, indoor air, garage air (if attached garage was present at residence), and outdoor air samples were collected.

6.2.8 SUMMARY OF INVESTIGATIVE ACTIVITIES COMPLETED BETWEEN APRIL 2006 AND JANUARY/FEBRUARY 2010

Study methods were described in the *Revised Supplemental Investigation Work Plan* (CEMC 2006a, for work conducted between May 2006 and August 2008) and addenda (CEMC 2006b, 2006c, and 2008c) and the *Additional Vapor Intrusion Investigation Sampling and Analysis Plan* (CEMC 2009a, for work conducted in March 2009 and January/February 2010). Details for events conducted between May 2006 and August 2008 were included in the *Supplemental Investigation Interim Report* (CEMC 2008d). Details for the March 2009 and January/February 2010

events were included in the *Supplemental Investigation Pathway Evaluation and March 2009 Additional Vapor Intrusion Investigation Results* (CEMC 2009d) and the *Supplemental Investigation Pathway Evaluation and January/February 2010 Resampling Investigation Results* (CEMC 2010c). Copies of the investigation reports (CEMC 2008d, CEMC 2009d, and CEMC 2010c) are provided in Appendix 6-G. The sample collection methods described in these work plans and reports include installation and sampling methodology for sub-slab soil gas, “deep” soil gas, near slab soil gas, multi-level nested soil gas, indoor air (including crawlspace air and garage air), and outdoor air samples. Soil gas probes were developed through pneumatic testing and purging prior to sample collection. For sampling events conducted in 2006 and 2007, 1,1-difluoroethane (1,1-DFA) was used as a leak detection compound during sampling to check for ambient air leaks during sampling. For events conducted after 2007, helium was used during purging and sampling to check for ambient air leaks within the equipment connections and fittings, the basement slab, or the annular seal in the soil gas probe.

All soil vapor and air samples collected in May 2006, September/October 2006, January 2007, and June 2007 were analyzed by Alpha Woods Hole Laboratories (Alpha) located in Westborough, Massachusetts. Samples collected between 2006 and 2007 were primarily from the seven multi-level nested wells located in public right-of-ways and from the near-slab wells located within five feet of sampled structures. Samples collected after 2007 were primarily collected from within and beneath structures and were analyzed by Columbia Analytical Services (CAS) located in Simi Valley, California. Additionally, duplicate samples were collected during the January 2007 and June 2007 for QA/QC purposes and were analyzed by Air Toxics, Ltd (ATL) located in Folsom, California and CAS. All sub-slab, near-slab, and multi-level soil gas monitoring samples were analyzed for VOCs using USEPA Method TO-15 and Massachusetts Department of Environmental Protection (MADEP) Air-Phase Hydrocarbon (APH). Analyses were also conducted for atmospheric gases (including oxygen and carbon dioxide) by ASTM Method D 1945 or by USEPA 3C.

The scope of investigation was designed to satisfy the requirements of the OSWER Draft VI Guidance and to provide sufficient information for determination of the completeness of the vapor intrusion pathway. During the course of this evaluation, 564 samples were collected from 48 structures and 7 multi-level nested wells over a five-year period. Samples were collected across all four seasons and during both high and low groundwater elevation events, allowing for evaluation of the VI pathway over the range of anticipated conditions in Sunburst. Specifically, CEMC performed the following:

- Seven multi-level nested soil gas monitoring wells (SIVW1 – SIVW7) were installed to allow collection of soil gas samples at incremental depths, from the top of the capillary fringe (approximately 1.5 to 2 feet above the highest measured groundwater elevation, as determined for each individual well location), and then decreasing in depth at regularly spaced intervals thereafter (approximately 5 feet) with the shallowest soil gas monitoring point not less

than approximately 5 ft-bgs. The nested wells were located in proximity to groundwater monitoring wells to allow for pathway evaluation from the dissolved phase source to the ground surface throughout the vadose zone.

- Near slab soil gas monitoring wells were installed within two meters of the foundation at 27 individual residences and one church (SI 01 through SI 26 and SI 28). Probes were installed at incremental depths from the top of the capillary fringe (approximately 1.5 to 2 feet above the highest measured groundwater elevation, as determined for each individual well location), and then decreasing in depth at regularly spaced intervals thereafter (approximately 5 feet) with the shallowest soil gas monitoring point not less than 5 ft-bgs. In some cases, only a single probe was installed due to the presence of shallow groundwater. Several attempts were made to install a near slab soil gas monitoring well at location SI 27, but the depth to groundwater was too shallow to allow for successful probe installation (i.e., the sample probe was submerged). At this location, indoor air and crawlspace samples were collected in place of being able to install a near slab monitoring well.
- Seventeen soil samples were collected during the May 2006 installation of soil gas monitoring wells and submitted to PTS Laboratories, Inc. (Santa Fe Springs, California) for geotechnical analyses to provide site-specific data to be used as inputs for modeling of indoor air concentrations. MDEQ's April 2011 VI Guidance (MDEQ 2011) does not allow for the use of the Johnson and Ettinger model to rule out risk of vapor intrusion. Rather, MDEQ requires the collection of indoor air samples and the evaluation of the pathway via multiple lines of evidence. However, the Facility's VI investigation was conducted prior to issuance of the April 2011 VI Guidance.
- Indoor air samples were collected at 40 locations (SI 01 through SI 14, SI 23 through SI 42, SI 44 through SI 47, SI 49, and SI 50), in conjunction with collection of sub-slab (and/or crawlspace air) samples and garage air samples (if attached garage was present). Additionally, during the May, July, and August 2008 sampling events, an outdoor air sample was collected at each residence where indoor air was sampled to allow for evaluation of potential background sources in ambient air. A building survey and occupant questionnaire were presented to the residents at each location in order to communicate with the community, gather relevant information about building design and condition, and identify potential interior sources of vapors. The "occupied dwelling questionnaires" were used to identify home construction types and lifestyle factors that may affect sample collection and results.
- Sub-slab vapor monitoring probes were installed at 26 locations (SI 03, SI 04, SI 06 through SI 11, SI 13, SI 14, SI 23 through SI 25, SI 28, SI 30, SI 31, SI 35, SI 37, SI 39 through SI 42, SI 44, SI 46, SI 47, and SI 50). In general, two sub-slab sampling points were installed at each location during each sampling event. The sub-slab soil gas samples from each probe were submitted for laboratory analysis of concentrations of target chemicals, in accordance with the OSWER Draft VI Guidance. During the March 2009 event, the chemical list was expanded to allow for further evaluation of non-plume related indoor air chemicals. Sub-slab probes were also monitored for fixed gases including oxygen (O₂), carbon dioxide (CO₂), and methane (CH₄) to assist in evaluating

biodegradation. Pneumatic testing was performed to assess the soil gas permeability beneath each structure. The sub-slab sampling locations were selected following completion of detailed home surveys and execution of access agreements from property owners. Sub-slab locations were biased away from the edges of the building foundation when possible.

- Crawlspace samples were collected at 24 locations (SI 01, SI 02, SI 05, SI 08 through SI 10, SI 12, SI 23, SI 25 through SI 27, SI 29, SI 31 through SI 34, SI 36, SI 38, SI 40 through SI 42, SI 45, SI 47, and SI 49) where there was neither a concrete floor basement nor slab on grade construction to allow for the collection of sub-slab samples. Crawlspace samples were also collected from several locations that contained both a competent concrete floor and a dirt crawlspace or basement floor, in order to more fully evaluate the vapor intrusion pathway.
- “Deep” soil gas probe samples were collected at four residences (SI 09, SI 23, SI 32, and SI 34) during the March 2009 event at locations with dirt crawlspace or basement floor where adequate space was available to allow for probe installation and saturated conditions were not encountered in the shallow subsurface beneath the residence.
- Two outdoor ambient air samples (OA1 and OA2) were collected on each day that near slab and nested well vapor samples were collected. During sampling in March 2009, a third outdoor ambient air sample (OA3) was collected each day sampling activities occurred. The locations where outdoor ambient air samples were collected are depicted on Figure 6.2-1. The outdoor ambient air samples were submitted for laboratory analysis to characterize ambient air quality and assist with understanding the potential contribution of vapors from ambient sources. Additional ambient air samples were collected near each residence during sub-slab and indoor air sample collection during 2007 and 2008. MDEQ approved CEMC’s request to use on central outdoor air sampling location for the 2010 sampling event as well (shown as location OA4 on Figure 6.2-1).
- One groundwater monitoring well (SIGW-1) was installed and sampled to further assess groundwater quality in the vicinity of location SI 28. A soil sample was collected during installation of the boring for well SIGW-1 and submitted to Lancaster Laboratories for analysis of VPH according to MADEP methodology, as well as VOC analysis (including 1,2-dichloroethane [1,2-DCA] and 1,2-dibromoethane [EDB]) by USEPA Method 8260, and tetraethyl lead analysis by USEPA Method 8270C, in accordance with Addendum No. 3 of the Revised SI Work Plan.
- Seventeen soil borings were installed in the area surrounding the residences at SI 02 and SI 05 to further delineate shallow soil quality. Soil samples that exhibited the highest measured PID concentration from each boring were submitted to Lancaster Laboratories for analysis of VPH according to MADEP methodology.



6.2.9 DATA VALIDATION

A Tier III data validation was completed for the soil vapor and air data collected for the vapor intrusion investigation, following the methodology outlined in Section 2.2. There were a total of 37,092 soil vapor and air data points. Results of the data validation are as follows:

- Alpha reported 7,368 of the 37,092 data points. The issued data sets were found to be 96.3% complete with a total of 273 rejected data points. Additionally, 2,150 data points were J or UJ qualified. If values were assigned a J or UJ qualifier, the data may be used for qualitative and quantitative purposes, with the reasons for qualification being given consideration when interpreting sample concentrations.
- CAS reported 29,614 of the 37,092 data points. The issued data sets were found to be 99.8% complete with a total of 67 rejected data points. Data was rejected primarily due to sample leakage during sample collection. Additionally, 994 data points were J or UJ qualified. If values were assigned a J or UJ qualifier, the data may be used for qualitative and quantitative purposes, with the reasons for qualification being given consideration when interpreting sample concentrations.
- The data reported by Air Toxics represented 110 of the data points. The majority of this data was assigned an R qualifier due to leakage issues while sampling. This data was only collected for QA/QC purposes and did not affect the outcomes of the investigation.

For additional details regarding the data validation, please reference CEMC 2008d, CEMC 2009d, and CEMC 2010c (Appendix 6-G).

6.2.10 SUMMARY OF FINDINGS

A vapor intrusion pathway analysis was completed using the data collected between 2006 and January/February 2010. The primary data set used to evaluate pathway completeness was the indoor air, sub-slab, crawlspace, and garage air data, which was primarily collected between 2008 and January/February 2010. Outdoor air data collected during these sample events was used to evaluate the potential contribution of outdoor air on indoor air quality. The nested well and near slab data, primarily collected in 2006 and 2007, were used as a secondary data set to support the findings from the other sampling events. The pathway evaluation conducted by CEMC considered background, alternate sources, and biodegradation from the source to indoor air. The MDEQ completed an independent pathway evaluation of the same data set.

Based on both Chevron and MDEQ's interpretation of the data, the pathway was determined to be incomplete at all of the structures sampled with the exception of the structure referred to as SI 03. At four of the structures sampled

(referred to as SI 14, SI 26, SI 27, and SI 41) MDEQ determined that no further action was required following the March 2009 sampling event and these structures were not included in the January/February 2010 resampling event since none of the measured petroleum-related constituents measured in indoor air exceeded their respective indoor air screening levels. Additionally, a few of the structures (SI 02 and SI 05) were demolished during the SI investigation; therefore, no further investigation was performed. The remaining structures were resampled as part of the January/February 2010 event. MDEQ sent letters the owners of each of the structures sampled during January/February 2010 indicating that the pathway was determined to be incomplete and that no further action was being required of CEMC (with the exception of SI 03). These letters were dated June 11, 2010 and stated, “Based on the 2009 and 2010 analytical data and all other evidence, DEQ will not require any additional actions related to vapor intrusion on your property.”

In correspondence dated April 16, 2009, MDEQ provided CEMC with a summary evaluation of analytical data collected at SI 03, and required CEMC to install a vapor mitigation system at this residence, based upon “the unacceptable risk posed by exposure to the concentrations of C₅-C₈ aliphatic hydrocarbons that were detected in the sub-slab and in the indoor air” as determined by MDEQ. CEMC installed a sub-slab depressurization (SSD) system at SI 03 in June 2009, as required by MDEQ and in accordance with the MDEQ-approved work plan entitled *Protective Vapor Mitigation System Work Plan, Location SI 03, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2009b). Operation and maintenance activities have continued at SI 03 since the installation of the mitigation system and have been reported to MDEQ in a series of O&M reports (CEMC 2010b and CEMC 2011b).

6.3 INVESTIGATION OF DEBRIS/DUMP AREA

As discussed in Section 4.5 of the Phase II RI Work Plan, representatives from WET had reported the presence of a dump/area of debris located approximately 3,800 feet to the west of the southern edge of the former refinery tank farm area. The location of this area is depicted on Figure 6.3-1. WET representatives further reported this area had been used by the former refinery to dispose of hydrocarbon impacted materials, although no evidence supporting this claim was provided. At the request of MDEQ, CEMC investigated this debris/dump area to assess its relationship to former refinery activities. The investigation consisted of a physical inspection of the debris area combined with a records review at the Montana Board of Oil and Gas (MBOG) in Shelby, Montana. The results of the investigation are presented in the following sections.

6.3.1 BACKGROUND AND INVESTIGATION METHODS

The suspected dump appears to bisect a portion of the southwest section line of Section 13 and 24 of Township (T) 36 north (N), Range (R) 3 west (W), as shown on Figure 6.3-1. More specifically, the area is located in the northwest

quarter of the northeast quarter of Section 24, T36N, R3W and the southwest quarter of the southeast quarter of Section 13, T36N, and R3W. WET representatives previously reported this area was used by the former refinery as a dump for hydrocarbon impacted materials, and one soil sample collected from that area by WET had a reported detection of TPH. While concrete, wood, and other debris were observed during a physical inspection of the area, there is no indication that the material is associated with the former refinery. Additionally, steel piping, such as that used to tie guidelines to support a drilling rig, were observed in the ground. Based on those observations, it was thought that the site may be associated with a former petroleum exploration well.

On May 19, 2010, CEMC reviewed records maintained at the MBOG to determine if exploration wells had been drilled in the vicinity of the dump site. Copies of the records reviewed are provided in Appendix 6-H. According to available records and hard copy plat maps, three wells were drilled within Sections 13 and 24 of T36N, R3W, as follows:

- One well, located in the southeast quarter of Section 24, was completed as a dry hole and then plugged and abandoned in 1943. Based on the *Log of Oil or Gas Well* document number API-101-07230, it appears that the Washington Oil Finding Company performed the drilling and also plugged and abandoned the well.
- Exploration wells had been drilled at two locations in the northwest quarter of Section 13:
 - Installation of a well was attempted within the northwest quarter of Section 13 in 1985 and again in 1986. The well was located 330 feet from the north Section line and 820 feet of the west Section line of Section 13. Initially, Berenergy Corporation attempted to install a well on land leased by Sun Lease. Drilling commenced on December 27, 1985. However, this location was abandoned on January 24, 1986, as shown on the *Log of Well* (Well No. 1 or 25-101-23018). A *Sundry Notices Report of Wells* filed with the MBOG on November 6, 1986, indicated this well was plugged and abandoned. In addition to that first drilling attempt, records in the form of a *Completion Report* dated November 27, 1986 and *Subsequent Report of Abandonment* dated February 16, 1988, indicate a second attempt was made to install an exploration well at this same location. The second drilling attempt was made by Bluejay Resources, Inc., and again the well was completed as a dry hole, then subsequently plugged and abandoned. The 1986 *Completion Report* was finalized/approved April 10, 1990. Note that this well is identified both as Well No. 1 and as Simmes Ranch No. 1 in the aforementioned documents.
 - Installation of another well in a different area of that same northwest quarter of Section 13, located 990 feet from the north Section line and 1,320 feet from the west Section line, was attempted in 1986. This well, identified as *Well No. 2*, was completed as a dry hole in December 1986, as documented by the *Completion Report Number 25-101-23098*. Bluejay Resources, Inc. was listed as the drilling contractor with Simmes Ranch shown as the lessee. Paperwork documenting the plugging and abandonment of this well was finalized

in February 1988. As with Well No. 1, this well is identified both as Well No. 2 and as Simmes Ranch No.2 in the aforementioned MBOG records.

The above information is summarized in Table 6.3-1. Locations of these exploration wells are depicted on Figure 6.3-1 and copies of the records referenced are provided in Appendix 6-H.

6.3.2 RESULTS

The records reviewed at the MBOG offices indicate there is some history of oil/gas exploration, including installation of exploration wells, in the general area of the suspect debris/dump area and significantly distant from the former refinery. Although none of the three exploration wells described in Section 6.3.1 coincide with the location of the suspect debris/dump area, the spatial distribution of documented exploration wells suggest the debris/dump area is associated with oil/gas exploration activities. While there were no records reviewed at the MBOG offices indicating an exploration well had been drilled at or proximal to the debris/dump area, it is possible such an activity could have been performed but not documented, given the age and paucity of some of the records reviewed. It is also possible the debris/dump area served as a staging or disposal area for other exploration activities, particularly when considering the materials observed at that location.

More importantly, the distance of the debris/dump area from the refinery would make disposal of refinery related waste infeasible at that location. There were other disposal areas available to the former refinery and located much closer to its operational activities. Furthermore, Phase II RI activities completed to date indicate Facility impacts do not extend to the location of the debris/dump area. No further investigation or action by CEMC is planned for this area.

6.4 NORTHWEST TANK FARM ELECTROMAGNETIC ANOMALY

This section addresses investigations regarding potential subsurface piping at the Facility located in the northwest portion of the former refinery tank farm. A subsurface electromagnetic (EM) survey conducted by WET during 2009 suggested the presence of linear anomalies (i.e., potential piping runs) within the survey area. CEMC conducted an initial review of historical aerial imagery and utility corridor maps and based on that review, formulated theories as to what the linear anomalies may represent, which were presented in Section 2.1.1 of the Phase II RI Work Plan.

Section 2.1.1 of the Phase II RI Work Plan also outlined investigation activities to gather additional information relative to the linear anomalies, including obtaining additional information regarding origin, historic purpose, and ownership of pipelines represented by the EM anomalies. Results are presented in the following sections.

6.4.1 BACKGROUND AND INVESTIGATION METHODS

A subsurface EM survey conducted during 2009 in the northwest portion of the former tank farm by WET (serving as a third party consultant) indicated the presence of three separate linear anomalies, likely pipelines. Observed by MDEQ, WET confirmed the presence of underground steel piping (approximately 3 to 4 inches in diameter) through the excavation of test pits at targeted locations in October 2009. MDEQ then notified CEMC of the EM survey results. The communication from MDEQ, which includes a figure depicting the results of the electromagnetic survey and photographs of several of the test pits, is provided in Appendix 6-I. Information regarding the protocols utilized during the electromagnetic survey is not provided.

CEMC gathered information related to the potential pipelines during late 2009 and early 2010, and incorporated that information into the Phase II RI Work Plan, as outlined above. During the remainder of Phase II RI activities, CEMC performed additional tracings along one of the identified anomalies and researched additional records related to the origin, historic purpose, and ownership of pipelines at and near the Facility. Key photos and documents included in this review are presented in Appendix 6-J.

6.4.2 RESULTS

As shown on the EM Survey figure (Appendix 6-I), three linear anomalies are present in the northwest portion of the former refinery tank farm, all presumably representing some type of piping run. All three lines run in a northwesterly to southeasterly direction, at different angles and to different extents. Conclusions based on additional investigation of each of the three pipelines are as follows:

- Abandoned Water Line. This line trends northwest at an approximate 15 degree angle, and becomes the southernmost line as it moves west of the Facility. As part of its additional investigation activities, CEMC traced this line westward from the Town of Sunburst water storage tank, across the field, and to a Town of Sunburst waterline marker. The trace of the line is consistent with that shown on the geophysical survey results figure.
- Crude oil pipeline from the Darling Oil Field. West of the Facility, this line trends northwest to southeast at an approximate 25 degree angle and is referred to as the “middle” line of the three depicted on the WET EM survey figure. Key points associated with this line include:
 - Review of a historical figure produced by Texaco (included in Appendix 6-J) indicates this pipeline was part of the Darling Gathering System, and entered the refinery on the north (between Tank Berms 1 and 2, which contained historic tanks 8 and 1072). The pipeline transected at the refinery, extending southward to a pump house identified on the figure as “Homestake Oil and Gas Company Pump House #6”(on property now owned by CEMC).

- The historical Texaco figure shows the Darling Gathering System pipeline in the same location as the linear anomaly shown on the electromagnetic survey results image. As noted in Section 2.1.1 of the Phase II RI Work Plan, CEMC traced the pipeline, using a metal detector, as far west as Surface Drainage 03. The surface expression of the pipeline trench is still visible crossing the drainage.
- A review of ownership records, recorded right of ways (ROWS) and easements associated with the Darling Gathering System suggest an extensive pipeline involving a number of properties, including portions of the former refinery. This review is summarized in Table 6.4-1. However, this review did not include easements associated with use of the pipeline by other parties subsequent to the Darling Gathering System.
- More recently, the pipeline that was the Darling Gathering System may have been used to convey natural gas. The location of the pipeline is aligned with a marker post located south of Tank Berm 34; based upon the information on the sign located on the marker post, the most recent party to use the pipeline is the Natural Gas Processing Company (Worland, Wyoming). When contacted by CEMC representatives in 2009, during preparation for drilling activities associated with the CSM Work Plan, the Natural Gas Processing Company indicated that they did not own any pipelines in Montana. Current ownership of the pipeline is not known.
- Unidentified, Northernmost line. This line trends northwest at an approximate 45 degree angle. CEMC traced the pipeline crossing Surface Drainage 01 using a metal detector. During field reconnaissance, the pipeline was discovered to be exposed in Surface Drainage 01. The pipeline was heavily corroded and rusted, confirming that this pipeline is not active. Historic ownership and use of this line has yet to be determined. However, the trace of the pipeline is visible in 1937 and 1957 aerial photographs. Expansion of those photos and the pipeline trajectory suggest this line is likely associated with a water reservoir located northwest of the Town of Sunburst. It is surmised this line was used to convey water to the refinery and not used to convey petroleum products.

Figure 6.4-1 attempts to portray the above conclusions by presenting a compilation of historic photographs and plat figures (presented in Appendix 6-J) overlain with current Facility GIS layers. Based on the above information, of the three linear anomalies identified in the WET EM survey figure, only one appears to represent a pipeline used to convey petroleum products. That one line is consistent with the location of the Darling Gathering System, used to convey crude oil from a field northwest of the Town of Sunburst to a pump facility located south of the refinery process area. This line appears to have been utilized at a later date to convey natural gas. The actions taken to convert the conveyance from crude oil to natural gas are not known at this time.

Impacts from the pipeline most likely would occur in subsurface soils, based on the required line depth specified in easement documents (see Table 6.4-1). Based on the results of soil investigations conducted during the Phase II RI, and presented in Chapter 3.0 of this document, subsurface soil impacts in the general northwest area of the refinery



were limited to areas adjacent to Tank Berms 1 and 2 (see Figure 3-4A). Those impacts could be associated with the Darling Gathering System pipeline or with activities conducted in those tank berms. More importantly, no additional impacts were noted along the northwest extent of that pipeline, within the footprint of the former refinery.

Pipelines remaining at the Facility will be further evaluated as part of the Facility's feasibility study.

6.5 TANK/PIPING IN FORMER WASTEWATER LAGOON AREA

As part of the Phase II RI, MDEQ required CEMC to investigate “the use and history of a tank and associated piping found east of town in the former wastewater lagoon area. Town utility maps and diagrams indicate the piping runs from the refinery north to the intersection of 2nd and 3rd Streets and then runs west to east between 2nd and 3rd Street, under the railroad tracks and to a tank in the former wastewater treatment lagoon.” Furthermore, MDEQ required that “an investigation must be conducted to determine if soil and groundwater in the surrounding area have been impacted by use of the system” (from MDEQ correspondence dated May 16, 2008; see Appendix 1-A). This section of the document presents findings of research conducted by CEMC to meet this requirement.

6.5.1 BACKGROUND AND INVESTIGATION METHODS

MDEQ's statement that “a tank and associated piping” located east of town in the former wastewater lagoon area, were based on town utility maps and diagrams. Prior to its May 16, 2008 correspondence, MDEQ inquired in an email dated February 25, 2008, whether CEMC possessed any information about a “rumored tank” that was “installed by Texaco in the lake area east of town.” Included with that email (copy provided in Appendix 6-K) was an attached figure derived from the Town of Sunburst's sewer system and aerial photography. The figure showed the location of a sewer line originating from the area between 2nd Street and 3rd Street, and running east/southeast towards an unidentified rectangular feature.

6.5.2 RESULTS

CEMC reviewed a copy of a 1945 map of the town's sewer system provided by the Town of Sunburst. The rectangular feature is shown on the map and is identified as being a septic tank. The map identifies the “piping” as a 10-inch tile main sewer line from the town and extending to the rectangular feature/septic tank. A copy of the 1945 map is provided in Appendix 6-K.

On March 4, 2008, CEMC staff inspected the rectangular feature/concrete septic tank located east of town. In a March 7, 2008 email response (copy provided in Appendix 6-K) to MDEQ's February 25, 2008 email inquiry, information and observations made during the March 4 inspection were provided. As noted in that email response, the

septic tank is an approximately 20 foot wide by 50 foot long concrete structure, with outlets/effluent channels extending eastward and into the lake bed.

CEMC also requested that MDEQ provide any available information that it possessed and related to the existence of any piping from the former refinery and linking to the town's sewer system. No additional information has been provided to CEMC from MDEQ or any other party.



7.0 UPDATED SITE CONCEPTUAL MODEL

A conceptual site model is a summary of the site-specific conditions affecting the distribution, mobility, and fate of chemicals in the environment, and is used to assess and communicate the potential for human health and environmental risks. An evaluation of contaminant fate and transport mechanisms at the former refinery was first presented in the 1990 RI Report. A formalized CSM for the Sunburst Facility was presented in the 2001 SSI Report and the 2003 FS Report.

The Facility's CSM has evolved during the course of the former refinery's investigation history as new knowledge has been gained through expanded investigations, and also as a result of engineered processes/remedial actions that have altered conditions. An updated CSM for the Facility was presented in the CSM Update Report, based on assessment activities conducted since 2006, and focused primarily on data generated during investigations associated with the Phase II RI conducted in 2009 and early 2010. The CSM for the Facility has been again updated, utilizing information generated during the remainder of Phase II investigations performed during 2010 – 2012 after submittal of the CSM Update Report. This chapter presents the current CSM for the Facility.

As discussed in Chapters 3-6 of this Report, the nature and extent of refinery-related impacts have been identified to varying degree in the different media evaluated at the Facility. Shallow soil impacts identified in earlier investigations were partially addressed during remedial actions conducted between 1999-2001 and under authority of the Facility's VCP, although some remaining impacted shallow soils have been identified during the Phase II RI. The potential for vapor intrusion from refinery-related impacts to groundwater and/or presence of LNAPL has been thoroughly evaluated throughout the Facility, resulting in installation and operation of a sub-slab depressurization system at a single residence. Impacts to surface water (as a result of natural discharge of impacted groundwater to the ground surface) have been identified in the one drainage at the Facility where groundwater seeps are present. Impacts to sediment in that drainage have also been identified, as well as impacts to sediment in portions of the lakebed, where wastewater from the former refinery was discharged.

Although refinery-related impacts are present in other media at the Facility, and remedial action may be determined to be necessary to address them, their nature and extent is less than that observed in groundwater. Impacts to groundwater and understanding of the groundwater system are of primary importance for the Facility in terms of effect on other media and potential future remedial activities, and therefore, the primary focus of this chapter.

7.1 SITE OVERVIEW AND CHARACTERISTICS

Key aspects of a conceptual site model include definition of vertical and horizontal extent of impacts in all media, an evaluation of fate and transport mechanisms for contaminants in impacted media, and identification of potential receptors to contaminant migration. The ability to adequately address these aspects is dependent upon the physical characteristics and natural features at a site, and the general setting of the surrounding area. For the Sunburst Facility, that information is detailed in Chapter 1.0 of this Report. Certain Facility characteristics, most notably those pertaining to area geology and hydrology, contribute to the complexity of the CSM and are therefore again presented in the following sections. The conceptual site model presented herein integrates these characteristics with data from several different sources to develop a foundation for understanding subsurface fluid movement and the distribution of Facility-related impacts in all environmental media.

7.1.1 GEOLOGY

The Sunburst area lies on the east flank of the Sweetgrass Arch, which is locally referred to as the Kevin-Sunburst Dome (Zimmerman 1967). The sedimentary rocks that underlie the region form a northwest-southeast trending arch. Upper Cretaceous sedimentary units that outcrop in the area are (from oldest to youngest): the Kevin Member of the Marias River Shale, the Telegraph Creek Formation, and the Virgelle Member of the Eagle Sandstone (lower unit of the Two Creek Formation). The Telegraph Creek Formation and Eagle Sandstone have been locally eroded in the Sunburst area leaving the Kevin Member of the Marias River Shale as the uppermost bedrock underlying the Facility and town. The upper portion of the Kevin Member is highly weathered and fractured with an irregular erosional surface, and is unconformably overlain by Quaternary glacial drift or alluvium of varying thickness.

The Facility and town are situated upon a physiographic divide between more elevated topography characterized by rolling hills to the west and a broad north-south trending valley to the east, which is characterized by relatively flat and low topography (Figure 7.1-1). This valley was likely formed by the runoff water from the retreat of the Wisconsin Ice Sheet and was probably a tributary of the Marias River during Pleistocene time (Hunt 1955). Such glacial paleo-drainages are common in northern Toole County, Montana. The exact history of the drainage is not known, but it is likely that at various times in its geologic history it has been occupied by ice, flowing rivers, and glacial lakes. At present this valley is generally dry but contains several ephemeral lakes, including the lake that occupies the approximate area between the eastern Facility boundary and Interstate-15. The rolling hills to the west of town are 100 to 200 feet higher than the valley floor (Figure 7.1-2).

7.1.1.1 OVERBURDEN SEDIMENTS

Due to the significant difference in physical setting, the eastern and western portions of the Facility and town have experienced both different erosive forces and different sediment deposition. As a result, the surficial sediments in the eastern and western portions of the Facility and town have different physical properties. This determination was based on the lithologic review of previously installed boreholes combined with the results from the second stage of the Phase II RI, which included the installation of 27 new P2RI-prefix monitoring wells in the lakebed east of town and along the railroad corridor. These results have led to a revised conceptual model for the nature of the overburden sediments which were formerly considered a single unit and are now considered to include two separate units (defined herein as alluvial sediments and glacial drift sediments).

The lateral contact between the alluvial sediments and glacial drift is gradational and is difficult to map exactly. On the basis of topographic elevation and monitoring well logs, the contact has been mapped approximately as shown on Figure 4.5-1. This contact exerts significant hydrogeologic control over the flow of both groundwater and LNAPLs, and thus the locations of water-bearing zones and LNAPL impacts also provide insight as to where the contact is located (see Sections 7.1.2.2 and 7.2.2.2).

7.1.1.1.1 GLACIAL DRIFT

In the rolling hills west of the Facility, glacial drift occurs as outwash channels and kettle lake deposits consisting of silt, gravel, sand, and till. Generally these materials are dry and poorly cohesive. The glacial drift was deposited over the eroded portions of the Kevin Member of the Marias River Shale, and the thickness of the unit varies from less than 10 feet to greater than 50 feet (Figure 4.5-2).

7.1.1.1.2 ALLUVIAL SEDIMENTS

Along the eastern margin of the Facility and extending eastward into the ephemeral lakebed, the surficial sediments consist of clay, silt, and sand with some gravel lenses. Dense and generally moist clay is the dominant sediment type. Discontinuous, isolated lenses of coarse grained materials (fine sands to gravels) are intermixed with the clays. Like the glacial drift, the alluvial sediments were deposited over the eroded Kevin Member of the Marias River Shale, but erosion of the Kevin Member in the glacio-fluvial valley was more pronounced than on the hill to the west. Near the contact with glacial drift, the thickness of the alluvial sediments is typically 10-20 feet, but the unit thickens to the east. As an example, monitoring well P2RI-54SL, located within the lakebed east of the Facility, was drilled to a total depth of 103 ft-bgs and weathered shale was not encountered. It is likely that weathered shale is present at depth east of the Facility, but the paleo-valley was deeply incised and has been mostly filled in by alluvial sediments. An isopach

map of the alluvial sediments is shown on Figure 4.5-3. Image B in Figure 4.5-7 shows a cross sectional view of a geologic model which illustrates the thickening of the alluvial sediments in the valley to the east of the Facility.

7.1.1.2 WEATHERED SHALE

The Kevin Member of the Marias River Shale consists of dark gray marine shale with thin sandy partings. The upper portion of the Kevin Member is highly weathered and fractured. Over most of the central and western portions of the Facility the elevation of the weathered shale surface undulates gently while generally decreasing to the north and east (Figure 4.5-4). East of the Facility, the elevation of the weathered shale is uncertain. Based on drilling data from P2RI-54SL, the weathered shale is covered by at least 103 feet of alluvial sediments, which were likely deposited in a deeply incised paleo-valley. This paleo-valley is presently manifested by a topographic low, a marked decrease in the elevation of the weathered shale surface, and an increase in the thickness of the overlying alluvial sediments (Image B, Figure 4.5-7).

The thickness of the weathered zone within the shale is variable, ranging from less than 10 feet to more than 50 feet (Figure 4.5-5). The degree of weathering observed is variable over the areal extent of the Facility, but typically decreases with depth. The lower portions of the weathered zone are characterized by a transition to a less weathered, fractured shale system followed by competent shale at depth.

7.1.1.3 COMPETENT SHALE

The deeper unweathered portions of Kevin Member of the Marias River Shale consist of very hard gray to black marine shale with occasional thin and discrete fractures. The Kevin Member is approximately 600 feet thick beneath Sunburst and thickens to the west (Cobban 1976). The transition from weathered to competent occurs over the first 10-60 feet of depth within the shale unit. The elevation of the weathered-to-competent shale transition generally decreases from southwest to northeast across the Facility corresponding to topographic variation, but local undulations possibly related to preferential weathering zones or erosional incisions are also present (Figure 4.5-6).

7.1.2 HYDROGEOLOGY

The principal aquifers in the region are present in the Quaternary alluvial deposits, the Cretaceous Two Medicine Formation, and the Mississippian Madison Group. The availability of groundwater within the Quaternary deposits varies greatly depending on the nature, sorting, stratification, and lateral extent of the deposits. The Virgelle Sandstone (lower unit of the Two Medicine Formation) has been eroded locally but outcrops approximately four miles to the west of Sunburst. The Madison Formation is generally located at depths greater than 1,000 ft-bgs.

Within and around the Facility, groundwater occurs in three principal hydrostratigraphic units, which are more fully described in Section 4.5.2.1. To summarize briefly, the three hydrostratigraphic units are analogous to the four geologic units described above in Section 7.1.1, with the exception that the glacial drift and weathered shale are considered to function as a single hydrostratigraphic unit. Groundwater at the Facility occurs primarily within the uppermost weathered and fractured zone within the Kevin Member of the Marias River Shale, and within the coarser-grained portions of the alluvial sediments in the valley on the eastern side of the Facility. Limited amounts of groundwater also occur in discrete fractures and thin partings within the deeper, unweathered portions of the Kevin Member.

7.1.2.1 FLUID LEVEL MAPPING AND POTENTIOMETRIC SURFACES

Potentiometric surfaces have been mapped in the alluvial sediments unit and the weathered shale unit. In order to map the potentiometric surfaces, wells were grouped based on the hydrostratigraphic unit in which they are screened.

Because the uppermost weathered and fractured zone within the shale is the primary water-bearing unit at the Facility, wells that are screened across the overburden - weathered shale contact or the weathered shale - competent shale transition were grouped with those wells screened solely within the weathered shale. The potentiometric surface maps for the weathered shale use fluid level data from wells screened in any part of the weathered shale unit or glacial drift. The potentiometric surface maps for the alluvial sediments use fluid level data only from the wells screened completely within the alluvial sediments unit. Fluid level data from some monitoring wells in the weathered shale and/or alluvial sediments were not used for interpolating potentiometric surfaces, for various reasons, but most often because the well contained very little to no groundwater.

Potentiometric surface maps have not been constructed for the competent shale, as the existing fluid level data from wells screened in the competent shale indicates that groundwater occurrence and hydraulic head within the unit are distributed randomly. Also, the network of wells screened in the competent shale is relatively sparse, especially if dry or nearly dry wells are excluded from the monitoring data sets. In addition, at this point in time it is uncertain if any of the wells screened in this unit, and which do contain groundwater, provide fluid level data representative of equilibrium conditions because of extremely slow recovery (weeks to months) following purging or sampling.

A complete listing of the wells at the Facility is provided in Table 4.1-1. The hydrostratigraphic unit in which the well screen is located is listed in the fourth column from the right side. The last two columns on the right side of the table denote which wells were included and excluded from construction of potentiometric surface maps, and rationale if excluded.

In addition to the wells listed as excluded in Table 4.1-1, a particular well will only contribute fluid level data to a potentiometric surface map if that well was gauged during the time period of interest for the map. Specifically, only wells existing at the time of the fluid level gauging event were included in the potentiometric surface data set.

Alluvial Sediments Potentiometric Surface Mapping – Figure 7.1-3 shows potentiometric surface maps for the alluvial sediments for four quarters (September 2011 to May 2012). These maps are all very similar, and indicate that groundwater flow direction is from northwest to southeast over most of the mapped area, with a stronger west to east component in the northern part of the mapped area in the Town of Sunburst.

Weathered Shale Potentiometric Surface Mapping – Figure 7.1-4 shows potentiometric surface maps for the weathered shale for four quarters (September 2011 to May 2012). Some wells installed in the weathered shale unit are dry or very nearly dry, indicating that the screened interval of a dry well either missed the water-bearing zones at that location, or the weathered shale is not a continuously saturated unit at that location. Because of the variability in the nature and degree of weathering within the shale, it is reasonable to expect that the unit should not be continuously saturated, and gradient alone is not the only driver of groundwater movement. Fluid levels from these wells were not used when constructing these potentiometric surfaces.

The best understanding of groundwater movement currently available is obtained by combining information on groundwater gradient with information on groundwater occurrence. Groundwater occurrence and yield during pumping is discussed in Section 7.1.2.2. Areas where groundwater is absent (i.e., dry wells) are not considered on the potentiometric surface maps in Figure 7.1-4.

The major features shown on the weathered shale potentiometric surface maps are as follows:

1. The highest groundwater elevations are in the area immediately west of the former tank farm boundary, in the vicinity of wells P2RI-52S, SDW-19S, and GW-1. Generally groundwater flows east or north from this groundwater high, with the potentiometric surface generally replicating the topography.
2. A secondary groundwater high exists on top of the hill overlooking the Town of Sunburst on which the town's water tanks are constructed, in the vicinity of wells LSSI-30, GW-C-46S, GW-CS, and GW-H. Groundwater flows radially from this groundwater high.
3. There is a groundwater divide in the northwest area of the former tank farm which is approximated by a northeast trending line connecting GW-1 and LSSI-31. Northwest of this divide groundwater flows approximately north-northeast along the same directional trend as Surface Drainage 01. Southeast of this divide groundwater flows generally east toward the former refinery process area.

4. The potentiometric surface is depressed in the central portion of the former tank farm, in the vicinity of wells GW-K, LSSI-9, LSSI-16, and LSSI-34. This depression is coincident with an area where the thickness of the weathered shale increases (Figure 4.5-5), which may be a preferential weathering zone. LNAPL has entered several wells and borings in this area, including LSSI-9, LSSI-9R, LSSI-16, LSSI-16R, Boring I, and LSSI-7. The groundwater depression and the occurrence of LNAPL may be related to the increased degree of weathering in the shale in this area.
5. A large head differential (greater than 100 feet) exists between the weathered shale in the former refinery tank farm and the weathered shale on the east side of the Town of Sunburst along the railroad corridor. This combined with the decreasing elevation of the weathered shale unit and the dense impermeable clays exerting confining pressure above, make the weathered shale artesian on the east side of town and in the former refinery process area.
6. The potentiometric surface maps for all four quarters are very similar. The exact location of the groundwater divide mentioned in item (3) and exact shape of the depression mentioned in item (4) are likely the features affected most significantly by seasonal changes in groundwater levels. It appears that at lower groundwater levels (May 2012) the groundwater divide moves slightly toward the southeast relative to high groundwater levels (September 2011). The groundwater depression in the central tank farm area also appears to become more bowl-shaped at low water levels, while it is more channel-like at high water levels.

7.1.2.2 WATER-BEARING ZONES

This section discusses the spatial occurrence of groundwater at the Facility and the potential for wells to sustain groundwater extraction. The term “water-bearing zones” refers to areas in which groundwater occurs and recharges naturally. This term should not be confused with “hydrostratigraphic units” which refers to bodies of sediment and/or rock which are characterized by groundwater flow over some portion (though not necessarily the entirety) of its volume. Within each hydrostratigraphic unit, multiple water-bearing zones may be present, and there may be significant variability in recharge rate amongst the zones.

A high degree of variability in terms of height of the static water column and groundwater recharge rate exists in the groundwater monitoring wells installed at the Facility. Some wells are completely dry, while others can sustain groundwater extraction in excess of 200 mL/min with no decrease in water level. Some wells with a very small water column (i.e., saturated thickness) can sustain extended groundwater production, while other wells with very large water columns may take months, even years, to recharge completely if the well is evacuated. Data on the occurrence and sustainable extraction rate of groundwater for wells at the Facility were compiled, modeled, and mapped to better understand groundwater flow pathways and potential dissolved constituent pathways (Section 7.2.2).

Groundwater sampling has been conducted at the Facility on a routine quarterly basis and a great deal of subjective knowledge has been developed about groundwater yield and rate of recharge for wells. Because collection of a complete set of sample bottles (full COI sample suite) from a well entails the extraction of a significant volume of water (approximately three gallons), each groundwater sampling event can be thought of as a localized pump test.

To provide a semi-quantitative way to measure this information, the ordinal scale shown in Table 7.1-1 was developed. This scale groups wells into “production classes” ranging from 1 (groundwater recharges quickly) to 5 (dry wells, no groundwater present) based on observations of the amount of water extracted and water level in the well during groundwater sampling. Based on a review of groundwater sampling field forms from 2010 and 2011, as many wells as possible were assigned a production class value from the scale. Additional datasets, such as groundwater sampling field forms from 2012 and historical fluid level data for the SDW- and LSSI- prefix wells were reviewed on a selective basis to determine production class values for additional wells. A majority of the wells at the Facility were categorized and the production class values for each well are listed in Table 4.1-1. Modeling software was then used to interpolate between the production class values in three dimensions. The resulting volumes, shown on Figure 7.1-5, provide a map of water-bearing zones at the Facility. No attempt was made to separate wells by vertical screened interval or hydrostratigraphic unit. The map is a result of spatial interpolation between the production class values only.

Figure 7.1-5 shows the presence of two primary water-bearing zones, both situated in topographic lows. The larger water-bearing zone is located near the base of the hill, in the central and eastern portions of the Town of Sunburst. This water-bearing zone extends southeastward into the lakebed. A second water-bearing zone is located in a topographic depression on the southwest side of the hill overlooking the town. A third, much smaller, water-bearing zone is located in the shallow subsurface near the head of the drainage immediately south of the former refinery property. Notably dry areas include the shallow subsurface near Surface Drainage 01, both the shallow and deep zones in the southeastern corner of the former refinery property near the former Snow Cap refinery, both the shallow and deep zones on the large hill southwest of the former refinery, and the deep zone under refinery’s western tank farm.

7.1.2.3 GEOCHEMICAL FINGERPRINT ANALYSIS OF METALS IN GROUNDWATER

As a supplemental line of evidence for evaluation of hydrogeologic conditions, the chemical composition of a suite of metals in groundwater was analyzed using a geochemical fingerprinting method (USEPA 2004a, *Fingerprint Analysis of Contaminant Data: A Forensic Tool for Evaluating Environmental Contamination*). The geochemical analysis focused on the comparison of samples from separate wells to identify similarities and differences that may be related to connectivity between water-bearing units.

The geochemical fingerprint technique known as the FALCON method was used to identify the unique signature ratios of metals concentrations in groundwater. In the FALCON method, data are analyzed using data normalization and histograms to develop characteristic fingerprints of composition which may then be compared to other data sets using visual observation and linear correlation statistics. The technique is useful when several analytes of unknown origin are present.

The method was applied to metals concentrations because this data is sampled as part of regulatory compliance at the site, and many of the metals are naturally present in subsurface soil and rocks. Metals concentrations in groundwater are at least partly related to the groundwater flow path and hydrostratigraphic unit. Concentrations of naturally occurring metals provide a reasonable substitute, although the data must be interpreted with caution because metals in groundwater are strongly affected by sorption, chelation, and chemical oxidation-reduction processes. The intent of this analysis is not to conclusively prove connectivity or disconnectedness between certain locations, but rather to provide an additional line of evidence to evaluate hydrogeologic connectivity and flow paths.

The FALCON method involves the following steps:

1. Data Review

Data were subjected to an initial review to assess the type and quantity of information available. The data were examined to identify an analyte subset that comprises the majority of metals frequently detected in groundwater, and is representative of the chemistry in different flow regimes that may be differentiated by fingerprinting. Non-detects across all samples were not included if they could not contribute to sample differentiation. The data review process reduced the subset of analytes to barium, chromium, cobalt, copper, lead, nickel, selenium, and zinc. This subset was used for all samples.

2. Data Tabulation and Normalization

The data set was organized into a table (Table 7.1-2), and the subset concentrations were totaled to give a concentration in mg/L. The mass fractions of each analyte were calculated by dividing the concentration of each analyte by the total sample concentration for the set. In this manner, the data were normalized into dimensionless mass fractions for each component within each sample. The advantage of normalizing the data in this manner was that it removes the effects of dilution of the metals by addition of water.

3. Sample Histograms

The sample mass fractions were plotted on a histogram (Figure 7.1-6), which allowed a visual comparison of each sample's mass fraction distribution among the individual metals. The x-axis on the histogram was an ordered presentation of the individual constituents (chemical species). The y-axis was the mass fraction expressed as a fraction between zero and one. Visual inspection of the histogram indicated composition trends across all samples.

4. Linear Regression Analysis of Sampling Location Mass Fractions

The use of linear regression provided a method of quantifying the mass fraction patterns (histogram) among samples (locations). A strong coefficient of determination (R^2 value close to 1) between two sample locations suggests a similar source for their metals content, because they have constituent concentrations (mg/L) that uniformly differ by a constant (e.g., an evaporative concentration factor or leaching of minerals in fixed proportions). In this case, a plot of the mass fractions from the two locations would have a slope close to 1, because the mass fractions would be the same. The use of R^2 values arises to determine the goodness of fit for this assumption. In other words, when comparing two data sets, if the resulting R^2 value is close to 1, then the metals mass fractions are of similar proportions and therefore the metals are probably from a similar source (even though the concentrations may be different between samples). Samples with weak mass fraction R^2 values (<0.5) may be unrelated, or they may have been altered by mixing with water of a different composition. In addition, chemical effects that are not uniformly proportional across the analytes, such as selective species precipitation, sorption, and ion exchange, may cause deviations in mass fractions and the associated histograms, resulting in weaker correlations.

The R^2 value is determined using each unique combination of sample locations. The R^2 value is calculated using the Excel correlation coefficient (Pearson correlation coefficient) and squaring this value to obtain R^2 . The value ranges from 0 to 1, with 1 indicative of a perfect linear relationship that implies the mass fractions from the two locations are the same, and that the actual concentrations differ by only evaporation, dilution, or leaching of natural minerals in fixed proportions based on the availability or abundance. A compilation of R^2 values is presented in Table 7.1-3.

The linear regression analysis focused on the area along the eastern margin of the Facility where the alluvial sediments hydrostratigraphic unit is present. Wells screened in the alluvial sediments ("shallow" wells for the purpose of this discussion) were compared to wells screened in the weathered shale hydrostratigraphic unit ("deep" wells for the purpose of this section) to assess the similarity or dissimilarity of their groundwater metals compositions. Due to the variability in geochemical processes that affect metals concentrations, comparisons were generally limited to shallow-deep well pairs in close geographic proximity. For each well included in the analysis, the most recent available metals data was used.

The wells and data used in the fingerprinting analysis are listed in Table 7.1-2. Table 7.1-3 summarizes the fingerprint mass fractions and correlation coefficients. Histograms for each well are shown on Figure 7.1-6, with the shallow wells shown above the adjacent deep wells for ease of visual comparison. Results of the analysis at selected shallow-deep well pairs are summarized and compared with other hydrogeologic observations in Table 7.1-4.

Generally, the shallow-deep well pairs analyzed showed little similarity in their mass fractions, and this is consistent with hydrogeologic separation between the alluvial sediments and weathered shale hydrostratigraphic units. Exceptions where the metals mass fractions are similar between the shallow-deep well pairs (i.e., when the R^2 for the shallow-deep well pair is close to 1) may indicate areas of localized connectivity between the two hydrostratigraphic units.

It is strong evidence for connectivity, and a verification of the geochemical fingerprinting technique, when multiple independent lines of evidence indicate connectivity between the two units, such as at GW-20RS and GW-20D. At these wells, the metals fingerprint regression coefficient was 0.92, and observations of fluid levels recorded during groundwater sampling indicate that water level in either well will drop by 1-2 feet when water is pumped from the other well (Table 7.1-4). At other well pairs where the geochemical fingerprinting suggests connectivity between the two units, pump test observations are either not available or inconclusive. However, pump tests have indicated a lack of vertical connectivity at several locations where the geochemical fingerprints are very dissimilar (GW-NS/GW-ND, P2RI-16S/ P2RI-16D, P2RI-22S/ P2RI-22D, P2RI-26S/P2RI-26D), which also validates the results of the geochemical analysis. At P2RI-26S and P2RI-26D, significantly different TPH concentrations are also consistent with hydrogeologic separation. TPH concentrations at P2RI-26D are typically around 4 mg/L, but TPH has never been detected above 0.1 mg/L at P2RI-26S.

Overall, the results of the geochemical fingerprinting analysis indicate hydrogeologic separation between the lake sediment clays and the weathered shale in most locations, but flow between the units may occur in localized areas, likely due to leakage through coarser-grained portions of the alluvial sediments. The results suggest that the geochemical fingerprinting technique is reasonably accurate and consistent with other methods of assessing hydrogeologic connectivity, and may be applicable to other portions of the Facility where hydrogeologic flow paths are not well characterized.

7.1.3 SUMMARY OF HYDROGEOLOGIC CONDITIONS

The following is a summary of the occurrence, distribution, and effect of groundwater beneath the Facility. More specifically, the following provides a summary of the three hydrostratigraphic units present at the Facility.

7.1.3.1 ALLUVIAL SEDIMENTS

The alluvial sediments in the eastern portion of the Facility are primarily composed of dense clay. Thin lenses and stringers of sand are dispersed throughout the unit, and these layers are the primary conduits for fluid movement. The coarse-grained portions of the alluvial sediments function as a significant water-bearing unit, particularly within the Town of Sunburst and along the eastern margins of the Facility. The finer-grained zones of this unit exert a confining pressure upon the water-bearing zones within the alluvial sediments at depth, and upon the weathered shale below. P2RI-32S, P2RI-33S, and GW-4R are examples of wells screened entirely within fine grained material. These wells yield small amounts of water and recharge slowly. Although some wells installed in the alluvial sediments do not yield much water, no dry wells have been installed in this unit, indicating that most of the areal extent of the aquifer is saturated.

Potentiometric surface maps of the alluvial sediments unit show that groundwater gradient is generally to the southeast, with a stronger west to east component in the northern portion of the mapped area in the Town of Sunburst (Figure 7.1-3). Portions of the alluvial sediments unit, especially in the lakebed east of the former refinery property where the thickness of the unit is the greatest, have the potential to produce flowing artesian wells. Static water levels are above ground surface (but not above the top of the well casing) at P2RI-54SM and P2RI-54SL. Static water levels within one foot of the ground surface have been observed at P2RI-60S and P2RI-62S (Table 4.1-2).

The finer grained portions of the alluvial sediments generally behave as confining layers which prevent groundwater flow between the saturated portions of the alluvial sediments and the weathered shale. However, there is some evidence of flow between the two hydrostratigraphic units in certain locations, indicating that intersecting coarse grained zones occasionally allow vertical communication. Table 7.1-4 summarizes the monitoring well data from shallow-deep well pairs where the shallow well is screened in alluvial sediments and the deep well is screened in the weathered shale. The column titled "Fluid Level Communication Test" summarizes observations of water level in one well while groundwater was extracted from the other member of the pair (see explanation in Section 7.1.2.2). The column titled "Metals Fingerprint Regression Coefficient" gives a value which represents the similarity (or dissimilarity) of the composition of total metals in the groundwater in the two wells, irrespective of the effects of dilution (see discussion in Section 7.1.2.3). This value ranges from 1 (exactly the same metals composition) to 0 (completely different metals compositions). A value greater than 0.8 may be an indication of connectivity between the shallow and deep zones, while a value less than 0.5 may be an indication that the vertical zones are hydraulically separated. At most locations, the available data suggest there is no flow between the weathered shale and the alluvial sediments. There may be potential for mixing at specific locations, such as GW-11, GW-20RS/GW-20D, P2RI-19S/P2RI-19D, and P2RI-23S/P2RI-23D (Table 7.1-4).

7.1.3.2 WEATHERED SHALE

The weathered shale hydrostratigraphic unit contains the primary water-bearing zones over most of the Facility. The nature of the overlying sediments exerts a significant control over hydraulic conditions within the weathered shale. Two distinct lithologic units are recognized within the overlying sediments (Figure 4.5-1). In the western and central portions of the Facility, the weathered shale is overlain by glacial drift. In this area of the Facility, the potentiometric surface is typically at approximately the same elevation as the contact between the glacial drift and weathered shale, and the saturated zone volume within the glacial drift is relatively small (for example, see Figure 7.1-7). Although the glacial drift may have different hydraulic properties than the weathered shale, the available data suggest that groundwater is present in the glacial drift only if there is sufficient groundwater to saturate the available pore space within weathered shale below, and that there is direct communication between the groundwater present in both geologic units. Thus, the glacial drift and weathered shale function as a single hydrostratigraphic unit.

In the eastern portion of the Facility the weathered shale is overlain by alluvial sediments. The majority of the alluvial sediments consist of dense clays which function as a hydrologic barrier between localized water-bearing zones within the coarser grained portions of the alluvial sediments and the saturated portions of the underlying weathered shale. In this area of the Facility, groundwater within the weathered shale is under confined and artesian conditions at most locations.

The elevation of the weathered shale is highest in the interior of the Facility along the northern edge of the tank farm. Hydraulic head in wells screened in the weathered shale in this area is typically between 3,420 to 3,440 ft-amsl. To the east and north, the elevation of the weathered shale decreases and the overlying sediments transition from glacial drift to less permeable alluvial sediments. Artesian conditions have been observed in several monitoring wells screened in the weathered shale within the Town of Sunburst and along the eastern margin of the Facility (e.g., Figure 7.1-7, P2RI-18D). In this area, observed heads decrease rapidly eastward, from 3,375 ft-amsl to 3,325 ft-amsl within approximately 1,000 horizontal feet (Figure 7.1-4). The artesian conditions are produced by the combination of 100+ feet of head differential between the weathered shale in the interior of the Facility and the eastern margin, and the confining pressure exerted by fine-grained layers in the overlying alluvial sediments. Groundwater under confined and artesian conditions in the weathered shale has the potential to discharge into and mix with groundwater present in the overlying alluvial sediments. Under natural conditions, this occurs only in localized areas where intersecting coarse grained layers within the alluvial sediments allow vertical leakage.

Due to variability in weathering intensity and fracture orientation within the shale, groundwater occurrence and flow directions are complex. The best data available on groundwater flow direction within the shale comes from analysis of

potentiometric surface maps (Section 7.1.2.1) in conjunction with the maps of water-bearing zones described in Section 7.1.2.2.

Potentiometric surface mapping indicates that groundwater flows generally from the high-elevation areas in the southwest portion of the Facility north and/or east to lower elevations (Figure 7.1-4). Mapping of water-bearing zones shows an area that can sustain relatively high groundwater extraction rates along the eastern margin of the Facility and in the central and eastern portions of the Town of Sunburst. Both the alluvial sediments and the weathered shale contain productive water-bearing zones in this area, but as discussed in Sections 7.1.2.3 and 7.1.3.1, there is a high degree of hydrogeologic separation between the two units. To the east the elevation of the weathered shale drops steeply. The water-bearing zone within the weathered shale may also extend eastward, though no boreholes have pierced the weathered shale east of the railroad tracks.

There is also a significant water-bearing zone in the topographic depression on the southwest side of the hill overlooking the Town of Sunburst (Figure 7.1-5). This water-bearing zone is located entirely within the weathered shale hydrostratigraphic unit. Potentiometric surface mapping (Figure 7.1-4) indicates that there is a groundwater divide in this area, north of which water flows north along the same directional trend as Surface Drainage 01. South of the divide, groundwater flows southeast. Mapping of water-bearing zones (Figure 7.1-5) indicates that the areas surrounding this water-bearing zone are generally dry or yield relatively small amounts of water, indicating that groundwater flow occurs in discrete pathways rather than over the entire volume of the unit.

Another water-bearing zone is located in the weathered shale along the southern boundary of the Facility (Figure 7.1-5). This water-bearing zone is smaller and yields less water than the water bearing zones to the north. Exploratory borings in the central and southern portion of the Facility's western tank farm indicate that the southern water-bearing zone is not connected to the larger water bearing zone in the vicinity of the P2RI-45 and P2RI-43 well clusters.

Because aquifer transmissivity is low and flow paths are complex, groundwater levels in newly installed monitoring wells often take several months and up to two years to achieve a state of equilibrium. Once a state of equilibrium is achieved, water levels generally vary seasonally within only a few feet. Maximum precipitation at the Facility occurs between May and July (Miller 1989), and some wells show maximum heads coincident with this time period. However, maximum heads are commonly not observed until August or September, which may indicate that the infiltration/recharge rate is slow. Groundwater produced from the weathered shale is poor in quality with high concentrations of sodium, magnesium, and nitrates. Total dissolved solids concentrations vary from 5,000 to

60,000 mg/L (Miller 1989). Salinity was reported at an average concentration of 1.78 percent in groundwater samples collected from the weathered and fractured portions of the Kevin Member between 2001 and 2009.

7.1.3.3 COMPETENT SHALE

Below the weathered shale is competent shale that is thin and discretely fractured. Some fractures are water-bearing or contain minor moisture. Other fractures are dry, but have mineralization or alteration products that indicate past fluid movement, while other fractures are completely dry and show no evidence of moisture, past or present.

Some monitoring wells installed in this unit have accumulated very large static water columns over time, but recharge from the deep fracture zones tends to be very slow if the water column is disturbed. For example, P2RI-56DF is screened in the competent shale from 3,356.5 to 3,326.5 ft-amsl. This well was installed October 26, 2011, and when first gauged on November 30, 2011, it had 0.85 feet of static water column. The second gauging event on March 15, 2012, indicated a 34.17 foot water column, and on May 16, 2012, the water column was 48.02 feet.

Many other wells screened in this zone show similarly long, slow, rises in groundwater level. Fluid level data collected by WET often show extreme increases and/or decreases in static water level which are not explained, nor have similar fluctuations in water level been observed by CEMC. For example, Figure 7.1-8 shows fluid levels versus time at well SDW-26D installed by WET. One day after the well was installed, approximately 40 feet of water is noted as present in the well, but this water column decreased to approximately 10 feet within a few months' time. WET's reports do not provide explanation for this significant decrease in water level. Since CEMC began monitoring this well in April 2010, a slow but steady rise in water level was observed until the static water column measured 50 feet during the summer of 2011. In August 2011, CEMC bailed the well dry in an attempt to gain a better understanding of static water level. Since that event, water level has slowly been rising within the well. Most wells screened in competent shale show similar variability in water levels, although water levels do not rise and fall uniformly in all wells.

Of the 30 monitoring wells CEMC installed in the competent shale, 20 (67%) are dry or nearly dry (Table 4-1.1). This indicates that the majority of the competent shale unit's volume is not transmissive, and groundwater does not flow according to a simple gradient. Instead, groundwater follows a complex pathway based on fracture geometry. Assessment of connectivity between different fracture zones is complicated by the long response time for any well after a perturbation of the groundwater system. Although the water in deep fractures is probably originally sourced from shallow water-bearing zones, the available data suggest there is not a connection between water present in the deeper fractured, competent shale and the shallower water in the weathered shale and Quaternary deposits.

7.1.3.4 REGIONAL HYDROGEOLOGY

Recharge to the Marias Shale and overlying Quaternary deposits occurs from precipitation and snow melt infiltration, as well as runoff from higher elevations. Additionally, leaks in the public drinking water supply system and irrigation of lawns artificially recharge the shallow groundwater-bearing zones beneath portions of town. During excavation activities conducted along 3rd Avenue (south of the High School), in the first half of 2009, several leaking water transmission lines were identified. These lines were reportedly discharging water at rates of up to several gallons per minute (gpm). These lines were capped or repaired, in coordination with the Town of Sunburst (WET 2010). Recent mapping of the shallow potentiometric surface shows the presence of a groundwater mound in the vicinity of the Sunburst water supply tank adjacent to areas where water supply discharge lines exist.

Groundwater present in the Quaternary deposits and the Kevin Member of the Marias Shale has the potential to discharge to ephemeral streams as springs where these units are exposed. Groundwater within these units may also discharge into the unnamed lake located east of the Facility following periods of heavy precipitation and snow melt.

The Virgelle Sandstone contains groundwater under both unconfined and confined conditions and is the principal aquifer in the region, supplying water to the Towns of Sunburst, Kevin, and Cut Bank. The aquifer outcrops 4 miles west of Sunburst and does not underlie the Facility. Groundwater production wells screened within the Virgelle Sandstone have reported yields of up to 250 gpm at 75 to 225 ft-bgs, with transmissivity ranging from 700 to 50,000 gallons per day per foot (Zimmerman 1967). The Town of Sunburst obtains its potable water from multiple wells located approximately 8 and 14 miles west of town. Aquifer recharge is from infiltration at outcrop areas and leakage from other aquifers.

The Madison Group is composed of interbedded crystalline limestones and shales containing water under confined conditions. This aquifer is located between 1,000 and 1,500 ft-bgs. The aquifer has both fracture and cavernous porosity which varies over short distances, causing a wide range in hydraulic properties. Production wells completed in the Madison Group may have yields of up to 500 gpm, with TDS concentrations of up to 7,000 mg/L (Zimmerman 1967). Groundwater produced from the Madison Group is unsuitable for domestic or agricultural purposes, but may have limited industrial applications.

7.2 SUMMARY OF FACILITY IMPACTS, NATURE AND EXTENT

The purpose of the Phase II RI was to define nature and extent of contamination at the Facility, and including impacts originating from the former refinery, as well as impacts originating from users of former refinery property that came to be placed there after the refinery ceased operation. In doing so, the Facility boundaries have been defined. Under

CECRA (§75-10-701(4), Montana Code Annotated [MCA]), the term “Facility” is defined as “all areas where a hazardous or deleterious substance has been deposited, stored, disposed of, placed, or otherwise come to be located”. Therefore, the Facility includes but is not limited to the original footprint of the former refinery site, expanded outward to include areas where hazardous or deleterious substances from the former refinery have come to be located.

The fate and transport of constituents in the environment are dependent on the nature of the materials in question, the pathways available for transport, and the properties of the media exposed to contaminants. Chemical mobility varies between media, e.g., soil vs. groundwater, and will often vary within a specific medium, based on variations in natural features and physical characteristics at a facility. It is, therefore, important to note that the extent of impacts may vary depending upon the media evaluated. The following sections discuss the extent of refinery-related impacts in five media: soil, groundwater, surface water and sediment, and vapor.

7.2.1 SOIL

The nature of soil impacts for the Facility, detailed in Chapter 3.0, is generally similar to that reported in prior documents, the most recent being the CSM Update and CSM Update Addendum. Detected constituents are those typically found at petroleum refineries, although as discussed in Section 7.4, there are a number of alternate sources for the most commonly detected constituents. Overall, refinery-related soil impacts generally are confined to the original footprint of the former refinery property, the exception being soils on certain residential properties within the Town of Sunburst. These soils were physically transported from the former refinery to residential properties for use as backfill on those properties, as discussed in Section 3.10, and are being addressed through interim actions. As these soils were not subject to natural fate and transport mechanisms, they were not used to define Facility boundaries with respect to impacted soil.

As stated above, the Facility boundary with respect to soil impacts generally coincides with the footprint of the original refinery property. Within this footprint, soil impacts are generally isolated within the western portion of the tank farm, and somewhat more widespread in the eastern portion of the former refinery. The highest density of samples with soil concentrations above the respective constituent screening levels occurs in the eastern portion of the refinery and in the former railroad loading rack area.

Considering the Facility as a whole, constituents exceed screening criteria in fewer than 30% of the surface soil samples. The most commonly detected constituents were PAHs (in up to 25% of the samples [benzo(a)pyrene]) and the heavier hydrocarbon fractions (up to approximately 30% for C11-C22 aromatic and C19-C36 aliphatic fractions).

The detection of VOCs and VPH fractions are relatively rare in surface soil (< 7% [toluene] and 3% [C9-C12 aliphatic fraction, respectively]).

When individual constituent concentrations in surface soil are compared to direct contact and leaching-based screening criteria (see Chapter 2.0), the constituents that exceed screening criteria most frequently are as follows:

- Benzo(a)pyrene exceeds the direct contact screening level in 14% of the surface soil samples
- Benzo(b)fluoranthene exceeds the direct contact screening level in approximately 5% of the surface soil samples
- Dibenz(a,h)anthracene exceeds the direct contact screening level in approximately 5% of the surface soil samples
- 1-Methylnaphthalene exceeds the direct contact screening level in approximately 5% of the surface soil samples
- C11-C22 aromatic carbon fraction exceeds the direct contact screening level in 5% of the surface soil samples

In subsurface soil, the most commonly detected constituents were also PAHs (in up to 15% of the samples [1-methylnaphthalene]) and the heavier hydrocarbon fractions (up to approximately 22% for C11-C22 aromatic and C9-C18 aliphatic fractions). VOCs and VPH fractions were detected slightly less frequently than PAHs and EPH. The most frequently detected VOCs in subsurface soil were sec-butylbenzene and 1,2,4-trimethylbenzene (13%) and the most frequently detected VPH fraction was C9-C12 aliphatic (17%).

When individual constituent concentrations in subsurface soil are compared to direct contact and leaching-based screening criteria (see Chapter 2.0), the constituents that exceed screening criteria most frequently are as follows:

- 1,2,4-Trimethylbenzene exceeds the direct contact screening level in 4% of the subsurface soil samples
- 1-Methylnaphthalene exceeds the leaching-based screening level in 13% of the subsurface soil samples
- C9-C18 aliphatic and C5-C8 aliphatic carbon fractions exceed the respective direct contact screening levels in 2% of the subsurface soil samples

With respect to inorganic constituents, lead exceeded the direct contact screening level in 6% of the surface soil samples and 2% of the subsurface soil samples, making it the primary inorganic constituent of concern. There were a few rare (<0.5%) exceedances of screening levels for antimony, copper, cyanide, mercury, and zinc. For arsenic, cobalt, and vanadium, screening levels are estimated background concentrations, which are based on the 95th UCL of the 90th percentile value. Therefore, a point-by-point comparison to these values is not technically appropriate. However, the maximum detected soil concentrations exceed the background values for each of these three metals. Determination of site-specific background concentrations of metals in soils has been determined and approved by

MDEQ, as discussed in Section 2.3.1. The calculated background values are presented in Appendix 2-D, as well as the Facility soil COI list (Table 2.1-1) and in the soil data summary tables that accompany Chapter 3.0.

In subsurface soil, constituents exceed screening criteria in fewer than 13% of the samples. Areas of subsurface soil impacts include primarily the former pipeline corridor in tank farm grid cell G7, VCP excavation areas 05 and 22, and the former railroad loading rack area. Thus, areas of impacted surface and subsurface soil appear to constitute only a small portion of the former refinery property. It is likely prior remedial actions, discussed in Section 1.4, addressed the majority of soil impacts associated with refinery operations, resulting in the residual the impacts described above.

The above information was utilized in additional evaluations to ascertain whether impacted soils have the potential to serve as continuing sources to other media, primarily surface water/sediment, and groundwater. The transport of impacted soils via wind deposition was addressed by the activities discussed in Section 3.4. As depicted on Figure 3.4-1, the concentrations of constituents in the program samples consistently met the applicable SLs, eliminating the need to further evaluate wind deposition as a transport mechanism.

The relationship between surface soil and surface water/sediment impacts was evaluated by considering the types of constituents detected in surface water/sediment, their spatial distribution relative to impacted areas of surface soil, overland surface water runoff pathways, and contributions from alternate sources. This evaluation is discussed in more detail in Section 7.5.

The potential for impacted soils to serve as a continuing source of impacts to groundwater was evaluated by again considering spatial distribution of carcinogenic constituents in surface and subsurface soils, relative to the distribution of TPH in groundwater. Additionally, soil boring lithology logs, monitoring well lithology logs, field forms, and field notes were reviewed to assess vertical extent of impacts. Soil samples submitted for laboratory analysis were typically collected from one or two soil boring intervals (see Section 2.1.1). To better assess vertical migration of constituents, field screening results (XRF, PID/FID) recorded for all intervals in a specific boring were evaluated in conjunction with the analytical results for the one or two intervals that were sampled for that boring. These additional evaluations are described in detail in Section 7.5.

7.2.2 GROUNDWATER

The nature and extent of groundwater impacts for the Facility, detailed in Chapter 4.0, had not been fully investigated at the time of submittal of the March 2010 CSM Update and June 2010 CSM Update Addendum. Additional investigations at the Facility were completed mid-2010 and through 2011, providing substantial information and

understanding of the groundwater system. The following sections provide a detailed and comprehensive overview of the properties of the groundwater system at the Facility, and the effects of refinery-related releases upon it.

7.2.2.1 DATA ANALYSIS METHODS

Selection of Analytes of Interest for Modeling - Although there are many dissolved phase constituents with elevated concentrations in groundwater at the Facility, it was necessary to limit detailed mapping and modeling to a small number of key indicators from which conclusions could be drawn for the CSM. Benzene and TPH were selected for detailed data analysis, mapping, and modeling.

Benzene is a key carcinogenic component of LNAPL, and due to its carcinogenic potential, it has a very low groundwater standard. Dissolved phase benzene concentrations are typically the most important driver for the remediation of groundwater at petroleum-impacted sites. Since the CSM is intended to guide future investigation and remediation at the Facility, benzene is the most important parameter for the purpose of mapping significantly impacted areas. In addition to benzene, TPH has been mapped to provide a more broadly encompassing map of hydrocarbon impacts. Both benzene and TPH require a relatively small amount of water to analyze, and both analytes have been on the Facility's COI list for most or all of the history of the environmental investigation. Thus, benzene and TPH provide the best spatial and temporal datasets available to assess groundwater impacts at the Facility.

Although the mapping of impacts based on benzene and TPH is generally representative of conditions across the Facility, there may be some locations which are not shown as impacted on figures depicting benzene and/or TPH data where individual parameters have occasionally or consistently exceeded MDEQ groundwater standards or RBSLs for other analytes. Figure 7.2-A depicts monitoring well locations outside the benzene and/or TPH plume where carcinogen constituent concentrations exceeding MDEQ groundwater standards or RBSLs have been detected. Included on Figure 7.2-A are pie charts depicting the constituents and number of exceedances. Concentration versus time charts were also created for these wells and are included as Figures 7.2-B through 7.2-O. For all other exceedances refer to Tables 4.6-1 through 4.6-4.

Selection of Modeling Data Values - Extensive drilling and groundwater quality monitoring has been conducted at the Facility since 1984. This program has been conducted in different phases and the objectives of the investigation have changed over time with the addition of new datasets. This integrated dataset represents the entirety of investigatory work done at the Facility. Due to the length of the site history and the phased nature of the environmental investigation, there is no "snapshot in time" that could be representative of all the work conducted at the Facility. Environmental variables, natural attenuation, and remedial activities (e.g., LNAPL recovery, pilot testing) have

affected dissolved phase constituent concentrations at the Facility over time. The current CSM describes current conditions at the Facility, but is based upon all available historical data.

The importance of historical data varies depending upon specific location. Boring M in the northwest portion of the former tank farm is an example of a location with a complex history and significant data. During the September 2007 installation of the sonic boring at location M, hydrocarbon impacts were noted at a depth of 15 ft-bgs, but were not observed in the intervals above or below that depth. Approximately 26 gallons of LNAPL was recovered from boring M between December 2007 and May 2008. The effective solubility of benzene in this LNAPL was 1.66 mg/L. Benzene was not detected above laboratory detection limits in a groundwater sample from boring M in May 2008. Boring M was converted to monitoring well GW-MDF in November 2010, and a second shallow monitoring well, GW-MS, was installed adjacent to it. Well GW-MDF produces very little groundwater when sampled, typically only enough for analysis of VOCs (120 mL). The four times that samples have been collected, benzene concentration has ranged from 0.035 mg/L to 0.14 mg/L. Well GW-MS has also been sampled four times, and benzene has never been detected above the limit of quantitation. During installation of the soil boring for well GW-MS, no significant hydrocarbon impacts were noted in the subsurface, in contrast to those observed during installation of sonic boring M; those shallow impacts either attenuated in this area, or are extremely localized to the area at boring M (now monitoring well GW-MDF). Based on this data, it is reasonable to conclude that the shallow aquifer at GW-MS is not impacted, and that the deep fracture system at GW-MDF is impacted but is at best indirectly connected to the residual LNAPL source zone that impacted boring M.

In contrast, some locations have much less data. For example, SDW-1D was sampled once by WET in July 2009. The reported benzene concentration was 0.0019 mg/L, which is less than the practical limit of quantitation for USEPA Method 8260B and the DEQ-7 Human Health Standard (HHS) for benzene in groundwater. Based on the available data, SDW-1D is not impacted.

So that data from different time periods could be effectively mapped and modeled to draw conclusions for the CSM, the following process was used to determine representative values of benzene and TPH concentration at each location. The process is intended to select a value that is similar to the concentrations that have been measured recently at each location. In effect, it is a *prediction* of what the concentration would be if the well was sampled in the near future. The data analysis was conducted in August 2012, prior to the third quarter groundwater sampling event of that year. All samples collected in July 2012 or earlier were used in the analysis. These representative values were used in the generation of all the figures in this section.

Benzene – The general process used to select representative values of benzene for all wells is illustrated in a flow chart on Figure 7.2-1. All wells where benzene has been analyzed and not detected above the limit of quantitation or where the maximum reported benzene concentration was below the DEQ-7 HHS (0.005 mg/L, also equal to the practical limit of quantitation for benzene by USEPA Method 8260B) were categorized as non-impacted, and the remaining wells were categorized as impacted. For each impacted well with four benzene data points, the Mann-Kendall trend test was used to test the data for a significant directional trend (i.e., whether the concentrations were increasing or decreasing over time). If the test indicated an increasing trend, the maximum reported concentration was selected as representative. If the test indicated a decreasing trend or the test did not achieve statistical significance at a 90% confidence level, the median value (the median of all un-qualified detections) was selected. Wells impacted by dissolved phase benzene, results of the Mann-Kendall trend test, and representative benzene concentrations are listed in Table 7.2-1. Concentration versus time charts for all impacted wells with 4 or more data points are provided in Appendix 7-A. Some wells have exceeded the DEQ-7 HHS for benzene at some point in time, but more recent data suggests that the concentration is currently below the standard. These wells are listed in Table 7.2-2. Non-impacted wells are listed in Table 7.2-3.

TPH – Representative TPH concentrations were determined by the process illustrated in a flow chart on Figure 7.2-2. The analysis was similar to the process described above for benzene, with the added complexity that TPH is detectable below the RBCA Tier I RBSL. The typical limit of quantitation for TPH by the MA-VPH method is 0.1 mg/L, while the RBCA Tier I RBSL is 1 mg/L. To utilize the data to the fullest extent possible for the purpose of understanding the source and migration of TPH, wells with TPH values typically below the RBCA Tier I RBSL have been mapped and considered separately from wells where TPH is typically not detectable. However, it should be noted that TPH values below the RBCA Tier I RBSL do not require corrective action. Wells impacted by dissolved phase TPH, results of the Mann-Kendall trend test, and representative TPH concentrations are listed in Table 7.2-4. Concentration versus time charts for all impacted wells with 4 or more data points are provided in Appendix 7-A. Wells where the TPH concentration has at some point exceeded the RBCA Tier I RBSL, but recent data suggest that the concentration is currently below the standard, are listed in Table 7.2-5. Wells where the maximum reported TPH concentration was greater than the limit of quantitation (0.1 mg/L) and less than the RBCA Tier I RBSL (1 mg/L) are listed in Table 7.2-6. Wells where TPH has never been detected above the limit of quantitation (0.1 mg/L) are listed in Table 7.2-7.

Calculation of Benzene Mole Fraction and Effective Solubility from LNAPL samples – For locations where LNAPL has been sampled at the Facility, the molecular weight of the LNAPL was estimated and the mole fraction of benzene was calculated using measured benzene concentrations and the estimated LNAPL molecular weight. LNAPL samples from a limited number of locations have been analyzed for carbon molecule size ranges by simulated distillation

(Table 7.2-8). This data produces the most accurate estimate of LNAPL molecular weight (and, hence, effective solubility of benzene to groundwater); however, this data is not available for all LNAPL samples. For the remaining LNAPL samples, the mass fraction of each n-alkane as a percentage of the total n-alkanes was used as an indicator of the distribution of all hydrocarbon molecules of similar size (Table 7.2-8). Using this data made it possible to estimate LNAPL molecular weight and benzene mole fraction for many more LNAPL samples. The effective solubility of benzene to groundwater was calculated from the benzene mole fraction (Tables 7.2-8 and 7.2-9). Effective solubilities of benzene from LNAPL samples were mapped and compared to dissolved phase benzene concentrations where available. In some cases, effective solubility data from wells that were abandoned and/or replaced are not representative of current conditions. These data have been considered in developing the CSM, but may not be shown on maps or cross sections of impacted areas.

For the purpose of mapping TPH concentrations, LNAPL occurrences were given arbitrary high values. Measured TPH concentrations in LNAPL samples are generally around 10^6 mg/L. As such, they are orders of magnitude greater than dissolved phase TPH concentrations in groundwater, and mapping TPH concentrations that high would “swamp out” the dissolved phase data. Therefore, arbitrary high values comparable to TPH concentrations measured in groundwater in locations where LNAPL is known to occur were mapped instead. These values are generally in the range of 5-20 mg/L.

Wells Lacking Data – Wells that have never been sampled for TPH or benzene generally fall into one of two categories: 1) Some wells will not yield enough water for the collection of a sample. 2) Some wells contain LNAPL which prevents the extraction of a groundwater sample. At a limited number of other locations, the reason for a lack of data is uncertain; generally these wells were installed for some purpose other than groundwater monitoring (for example, pilot tests or fluid level observations during aquifer tests), and they are not included in the Facility’s groundwater sampling program.

7.2.2.2 EXTENT OF HYDROCARBON IMPACTS

To define the extent of hydrocarbon impacts, LNAPL occurrences in monitoring wells, dissolved phase benzene concentrations, and dissolved phase TPH concentrations were mapped. By the process described in Section 7.2.2.1, each well at the Facility was grouped in one of four categories, as follows: 1) Impacted by LNAPL, 2) Impacted by dissolved phase benzene and/or TPH, 3) Not impacted, or 4) Dry. A figure was constructed for each hydrostratigraphic unit, showing the wells screened in that unit with map symbols corresponding to these four categories. Figure 7.2-3 shows the wells screened in alluvial sediments, Figure 7-2.4 shows the wells screened in weathered shale, and Figure 7.2-5 shows the wells screened in competent shale. Well screen locations, hydrostratigraphic units, LNAPL

occurrences in monitoring wells, and dissolved phase constituent concentrations were also mapped and modeled in three dimensions. Based on the three dimensional data analysis, it was determined that hydrocarbon impacts in the weathered shale and alluvial sediments could be considered and delineated simultaneously. Hydrocarbon impacts in the competent shale are located at far greater depths in a much different hydrogeologic regime, and thus are delineated separately.

Weathered Shale and Alluvial Sediments – In general, few wells screened in the alluvial sediments are impacted, and no wells in the alluvial sediments have ever been found to contain LNAPL (Figure 7.2-3). Also, for wells that are impacted and screened in the alluvial sediments, dissolved phase benzene, and TPH concentrations are relatively low. There is a much larger number of impacted wells in the weathered shale, and the spatial distribution of the impacted wells suggests complex groundwater flow paths and/or multiple source areas (Figure 7.2-4). This may indicate that hydrocarbon impacts in the alluvial sediments are generally related to chemical diffusion from impacted zones in the weathered shale below, rather than advective transport directly from source areas. An exception is well GW-11, which has the highest dissolved phase constituent concentrations of any well screened in alluvial sediments. GW-11 may be located in an area where there is advective vertical connectivity between groundwater in the weathered shale and the alluvial sediments.

Figure 7.2-6 shows a map of benzene concentrations in the weathered shale and alluvial sediments. The contour of 0.005 mg/L benzene delineates the portion of the Facility in which that parameter exceeds the DEQ-7 HHS. This line is derived from a three dimensional spatial interpolation of benzene concentrations and effective solubilities between the screened intervals of all wells screened in the alluvial sediments or weathered shale. The model is generalized to two dimensions by evaluating it upon the potentiometric surface. Within the area bounded by this line, a color flood map illustrates the magnitude of benzene concentrations, ranging from approximately 0.005 to 2.6 mg/L. Areas with higher benzene concentration are shown in pink, while shades of progressively lighter blue indicate lower concentrations. Similarly, TPH concentrations in the weathered shale and alluvial sediments are mapped on Figure 7.2-7, where a contour interval of 1 mg/L TPH delineates the portion of the Facility where TPH exceeds the RBCA Tier I RBSL. Within that contour, a color flood similar to the benzene figure illustrates variability in TPH concentrations.

These figures show that the distribution of benzene and TPH concentrations is non-uniform or “patchy” across the site. Wells with relatively high benzene and/or TPH concentrations may be located in close proximity to wells where neither analyte has been detected above the limit of quantitation. The irregular shape of the impacted area and irregular distribution of high concentration “hot spots” necessitate that the impacted area be discussed in detail in smaller portions. Impacted wells are grouped by proximity in Table 7.2-10, and the table summarizes the general

characteristics of the hydrocarbon impacts in each area. Four schematic cross sections were constructed to provide additional information on the distribution of hydrocarbon impacts in specific areas. The cross sections were generalized from three dimensional models of the site geology and benzene concentrations in groundwater. Locations of the cross section lines are shown on Figure 7.2-10.

One significantly impacted area occupies the approximate location of the gasoline plume identified by Texaco and is attributed to the 1955 pipeline release. This includes the weathered shale in the south-central portion of the Town of Sunburst and extending south of the town into the former refinery. Groundwater impacts in this area are generally confined to the weathered shale, while the overlying alluvial sediments are typically not impacted. Minor impacts have been identified in the alluvial sediments at GW-6R, GW-16R, and GW-12, most likely due to upward leakage or chemical diffusion from the weathered shale below. Within the weathered shale, monitoring well GW-ND marks the northern extent of elevated benzene concentrations. LNAPL has been observed in several wells in the Texaco gasoline plume area since 2006, including boring E, MWD-1, VW-2, and GW-13. Benzene mole fractions in these LNAPLs ranged from 1.4×10^{-8} at GW-13 to 1.02×10^{-3} at VW-2, corresponding to effective solubilities ranging from near zero to 1.82 mg/L. These values are in reasonable agreement with dissolved phase benzene concentrations in this area (typically 0.1 to 1.5 mg/L). TPH concentrations are highest (approximately 13 mg/L) in the southern portion of the area near well GW-13, and decrease to values ranging from 1-5 mg/L in the north. This area is also approximately coincident with the mapped contact between glacial drift and alluvial sediments (Figure 4.5-1). The impermeable clay within the alluvial sediments (and the confining pressure it exerts upon the weathered shale) may function as a barrier to eastward LNAPL movement, causing LNAPL to accumulate in this area. A cross section across this area is shown on Figure 7.2-11.

Several hundred feet downhill and to the east is another impacted area, which is separated from the area around GW-ES and GW-13 by several wells where benzene and TPH have not been detected above the limit of quantitation. This impacted area has relatively high dissolved phase benzene and TPH concentrations (typically 1 to 3 mg/L benzene; 5 to 20 mg/L TPH), but no LNAPL has been observed in this area. In the southern portion of the area, groundwater in both the alluvial sediments and the weathered shale is impacted. To the north, elevated benzene and TPH concentrations are confined to the weathered shale and the alluvial sediments are not impacted. Monitoring well SDW-11S (installed by WET) marks the northern extent of impacts within the weathered shale. However, impacts to groundwater at this location have significantly decreased since plugging and abandonment of upgradient monitoring wells cross-screened within impacted underlying weathered shale and overlying sediments. Therefore, the northern extent of impacts within the weathered shale in this portion of town is more likely in proximity to monitoring well P2RI-25D (approximately 175 feet south of SDW-11S). A cross section across this area is shown on Figure 7.2-12.

In the central tank farm area of the former refinery property, hydrocarbon impacts are centered on wells LSSI-9, LSSI-9R, LSSI-16, LSSI-16R, and LSSI-7. These locations are all part of the current LNAPL monitoring and recovery program at the Facility. Dissolved phase benzene concentrations and effective solubilities from LNAPL in this area are typically in the range of 0.5 to 1 mg/L, which is relatively low compared to other impacted areas of the Facility. This area is coincident with an increase in the thickness of the weathered shale (Figure 4.5-5), and a depression in the weathered shale potentiometric surface (Figure 7.1-4). These features may indicate a preferential weathering zone, which may function as a significant flow path between the water-bearing zone at the top of the hill and the water-bearing zone at the bottom of the hill to the east. The accumulation of LNAPL may be related to this feature, but the high rate of groundwater flushing due to the eastward gradient has likely stripped the LNAPL of a portion of its water-soluble fraction (ChevronTexaco ETC 2006, 2007c, Newfields 2008a), resulting in lower benzene concentrations in this area. Figure 7.2-13 provides a cross-sectional view of this area.

West of this area there is a fairly large but possibly discontinuous area of impacts in the Facility's western tank farm. Significantly impacted wells in this area include P2RI-6, P2RI-4S, P2RI-43S, LSSI-32, LSSI-36, and P2RI-45E. Dissolved phase benzene concentrations in these "hot spot" wells range from about 0.5 to 3 mg/L. The impacted wells are screened in the upper portion of the weathered shale, or across the contact between the weathered shale and overlying glacial drift. Deeper wells in the area (P2RI-4D and P2RI-43D) are not impacted, indicating that hydrocarbon impacts are generally confined to the upper portion of the weathered shale. The zone of hydrocarbon impacts and the potentiometric surface occupy approximately the same vertical space, and the groundwater is under unconfined conditions, so the LNAPL in this area may behave as expected in a typical smear zone. LNAPL has been found in this area both historically (sonic borings M, C-29, C-47) and recently (P2RI-45E – last detected May 15, 2012, GW-C-47S – last detected September 8, 2011). The available data on benzene content in this LNAPL indicates benzene mole fractions on the order of 10^{-3} and effective solubilities ranging from approximately 1 to 3 mg/L, which is in reasonable agreement with detected dissolved phase benzene concentrations of 0.02 to 3 mg/L. Dissolved phase TPH concentrations range from approximately 1 to 20 mg/L. Well density in this area is relatively sparse, with some shallow wells which are not impacted, indicating that the spatial distribution of hydrocarbon impacts is non-uniform or "patchy". Additional mapping of the smear zone in this area may be beneficial to support targeted remediation efforts. A cross section across a portion of this area is shown on Figure 7.2-14.

Several smaller areas of hydrocarbon impacts to groundwater are present in the weathered shale and alluvial sediments, with some being apparently isolated. These impacted areas include:

1. A relatively high benzene concentration (approximately 0.93 mg/L) at SD01-TP-01 (a temporary piezometer installed at the upper [southern] end of Surface Drainage 01), and trace benzene detections (about 0.006 mg/L) at

SD01-TP-03 about 200 feet downgradient. Benzene has not been detected in shallow groundwater monitoring wells in the immediate area, leading to the inference that SD01-TP-01 may be impacted by a localized benzene source. CEMC has investigated the potential source(s) of contamination to the groundwater seeps in SD01. Data collected during those investigation activities suggest that these seeps are sourced primarily from shallow groundwater and/or precipitation. The shallow potentiometric surface is very near the topographic surface in this area, and likely rises above the topography during periods of high groundwater level, consistent with the occurrence of ephemeral groundwater seeps in the drainage. Additional discussion of efforts to determine potential source(s) of contamination to the groundwater seeps in SD01 are presented in Chapter 8.0.

2. Two wells in Tank Berm 10 where LNAPL has been observed (P2RI-42S and TB10-RW). This LNAPL has very low benzene mole fraction (3.88×10^{-8}), and nearby well GW-7 is not impacted by benzene or TPH. Soil borings also indicate that these LNAPL impacts are confined to the area within the tank berm.
3. Well PA-1, which is surrounded closely by non-impacted wells but has a fairly large volume of LNAPL, and relatively high LNAPL mobility. The benzene mole fraction in this LNAPL is 2.74×10^{-4} , which corresponds to an effective solubility of 0.49 mg/L. This location is part of the current LNAPL recovery program at the Facility. Recent soil sampling activities (including installation of geoprobe borings, related to the forthcoming risk assessments (human health and ecological) for the Facility) in the former process area, and proximal to PA-1, indicate significant hydrocarbon impacts to vadose zone soil. Those impacted, relatively shallow soils (between 6 and 20 ft-bgs) may be the source of LNAPL at PA-1. This area will be further evaluated during the FS process.
4. An isolated area of elevated benzene and TPH (about 0.15 and 4.37 mg/L, respectively) in groundwater at well P2RI-53S, and a trace detection of benzene (0.018 mg/L) at nearby well P2RI-60S. These wells are screened in the alluvial sediments in the lakebed near/downgradient of the former refinery wastewater treatment lagoons.
5. An isolated area of elevated TPH concentration at well P2RI-56DF. This well was installed on October 26, 2011, and it has been sampled three times as of August 2012. The TPH and benzene concentrations have decreased with each sampling event, and most recently (May 2012) the benzene concentration was below the DEQ-7 HHS at 0.0037 mg/L, while TPH was slightly in exceedance of the RBCA Tier I RBSL at 1.56 mg/L.

Competent Shale – There are six wells screened in competent shale in the agricultural field northwest of the former tank farm which contain LNAPL (Figure 7.2-5). The screened intervals of these wells are in the range of 3,350 to 3,300 ft-amsl, corresponding to depths of approximately 110 to 150 ft-bgs. There is little or no groundwater present in any of the wells. The LNAPL has relatively high benzene mole fraction (on the order of 10^{-3}) and effective solubility (ranging from approximately 2 to 4 mg/L). In the immediate area south and east of the wells impacted by LNAPL, a few wells have dissolved phase benzene and/or TPH concentrations that are above the applicable groundwater

standards, but these concentrations are much lower than what would be expected if the groundwater was in direct contact with the LNAPL (Figure 7.2-8, Figure 7.2-9). The area has been delineated on all sides, and in both shallow and deep zones, by wells where benzene and TPH have not been detected. This indicates that the LNAPL is not affecting water-bearing zones; however it is also possible that the limited number of monitoring wells installed in this area and lithology may not have contacted fractures that contain LNAPL in this area. Figure 7.2-14 shows a cross section of a portion of the impacted area.

Forensic analysis shows that the chemical composition of the LNAPL in the wells screened in competent shale is similar to the composition of the LNAPL in (relatively) shallow well P2RI-45E and deep soil borings M and C-47, suggesting that the LNAPLs may share a common source. The LNAPL in the competent shale is slightly less weathered (Newfields 2008a, 2008c, 2010b), and is the least weathered of any LNAPLs collected from the Facility (Chevron ETC 2008, 2010, and Newfields 2008c, 2010b). High concentrations of soluble and volatile constituents retained in this unweathered LNAPL are consistent with its location in tight fractures deep within competent shale, with little or no contact with subsurface air or groundwater.

CEMC has installed 30 wells in the competent shale, which provide spatial coverage of the entire Facility. Apart from the wells in the northwest field discussed previously, all other wells in the competent shale are either dry or do not have detected benzene or TPH impacts (Figure 7.2-5).

7.2.2.3 FORENSIC CHARACTERIZATION OF HYDROCARBON TYPES

To characterize the LNAPL and dissolved phase petroleum hydrocarbon distribution at the Facility, LNAPL and groundwater samples have been collected and submitted for forensic analyses. The objective of the forensic analyses was to better understand the chemical nature of hydrocarbon impacts and identify any potential chemical variation in the LNAPLs or impacted groundwaters. The chemical data could identify potential source areas and possibly delineate areas impacted by particular sources. This data is discussed in the context of the conceptual site model in this section. For a description of the sampling methods and analyses see Section 4.10 of this Report.

Description of Hydrocarbon Types – Between 2006 and 2012 (ChevronTexaco ETC 2006, 2007a-c, Chevron ETC 2008, 2009, 2010, and Newfields 2008a-c, 2009a-c, 2010a-c, 2011a-b, 2012), three general LNAPL types have been identified in the surficial sediments and weathered/fractured shale beneath the Facility including:

- **Type 1:** Hydrocarbons comprised nearly entirely of compounds in the $<C_{13}$ range, with n-alkanes being the most prominent C_8+ compounds, and little or no evidence of higher boiling petroleum products (although trace amounts, $<1\%$ to approximately 10% total mass, of heavier range hydrocarbon are occasionally present, and are inferred to

be the result of mixing with Type 3 LNAPLs described below). Type 1 LNAPLs typically have densities in the range of 0.75-0.77 grams per milliliter. Overall the composition of this LNAPL type is consistent with a relatively unweathered straight-run gasoline (SRG), also called naphtha, which was a predominate component of most automotive gasoline refined prior to the 1970s (Newfields 2008a). Groundwater impacted by this type of LNAPL contains a predominance of monoaromatic compounds, dominated by toluene and xylenes, which is typical of the water-soluble fraction (WSF) of automotive gasoline (Newfields 2008a).

- **Type 2:** Hydrocarbons with particularly prominent n-alkanes in the C₈-C₁₃ range, and elevated C₉-C₄₄ TPH concentrations. These chemical characteristics are consistent with a relatively unweathered, light middle (e.g., kerosene, or diesel fuel) distillate (Newfields 2008a). Generally such hydrocarbons have been identified in impacted groundwater only, although a few samples have identified these middle-range hydrocarbons as a component in LNAPL mixtures. Because the middle-range component has never been the sole component of a LNAPL, its density is uncertain, but it is likely in the range of 0.78-0.81 grams per milliliter.
- **Type 3:** Hydrocarbons with a broad boiling range spanning from <C₈-C₃₅, and a general absence of n-alkanes. These chemical characteristics are indicative of heavier range hydrocarbons (e.g., crude oil, lube oil, gas oil, or residuum), with densities in the range of 0.85 to 0.91 grams per milliliter (Newfields 2008a and 2009c).

Mixtures of variable amounts of each of the three primary hydrocarbon types are also common. Within each type, exact chemical composition is variable. These variations are in some cases attributable to weathering differences, and in some cases may be indicative of different petroleum products with similar overall composition. Figure 7.2-15 shows the spatial distribution of the different types of LNAPL and dissolved phase hydrocarbons at the Facility. The distribution of each hydrocarbon type and potential source areas are discussed below.

Present Distribution and Potential Source Areas

This section discusses the distribution of each hydrocarbon type and attempts to relate the present distribution to known or suspected source areas for that type. This exercise necessarily draws on all the data previously presented in the CSM and also relies on inference or speculation when the available data are inconclusive. Therefore, the explanations offered in this section are subject to modification if/as additional data collection occurs.

Type 1 - Type 1 hydrocarbons are the most common at the Facility, and form the primary component of impacts in all of the larger impacted areas, i.e., areas within the Town of Sunburst, the former refinery process area, the central and western portions of the former tank farm, and the deeper, competent shale in the agricultural field northwest of the former refinery. The chemical variation amongst Type 1 LNAPLs is generally attributable to variable intensity of weathering processes such as water-washing and volatilization. Type 1 LNAPLs occurring in highly transmissive

water-bearing zones (e.g., MWD-1, boring E) are more weathered than Type 1 LNAPLs occurring in non-water-bearing zones (e.g., SDW-5). Chemical indications of such weathering include enrichment in non-water soluble compounds such as di- and tri-methylpentanes, and depletion in comparatively soluble compounds such as benzene, ethylbenzene, toluene, xylene (BETX) (Figure 7.2-16). Variable evaporation associated with the LNAPLs' location relative to the water table has also affected their composition. In general, however, Type 1 LNAPLs have very similar chemical characteristics. Given the groundwater gradient and flow paths relative to the release location, all Type 1 impacts can be reasonably attributed to the 1955 pipeline leak, although additional spill events cannot be ruled out. The particularly high TPH, VOCs and SVOCs concentrations in wells GW-11, GW-31, LSSI-39, and PTA3 may be attributable to a source (AST) near GW-31 (Newfields 2008a). However, no evidence of shallow soil impacts were observed during installation of well GW-31 in the area where the former AST was located, as would be expected if releases had occurred.

A preferential weathering zone and depression in the potentiometric surface immediately south of the pipeline release area may have caused LNAPL to accumulate there (near wells LSSI-9, LSSI-16, and LSSI-7). It is assumed that additional LNAPL moved eastward from the pipeline release area and accumulated along the contact between glacial drift and alluvial sediments near the base of the hill; the LNAPL then spread primarily northward along the contact due to the barrier to eastward flow formed by the tight clay within the alluvial sediments and the slight northward component of groundwater gradient. This area had been the primary focus of Texaco's remediation efforts (i.e., LNAPL recovery) at the Facility in the 1950s. A preferential groundwater flow path from the southern portion of this area eastward toward GW-11 allowed dissolved phase constituents to migrate east, contributing to impacts in that area, although some or all of the impacts in the area around wells GW-11 and GW-31 may be related to the previously mentioned former AST at the site of well GW-31. The fact that LNAPL has never been observed in any monitoring wells in the area argues against a source near well GW-31, but the tight clay lithology present in this area may hold LNAPL immobilized in the subsurface. At present, dissolved phase hydrocarbon concentrations in groundwater in the GW-11/GW-31 area are considerably higher than those observed in the area to the west, which may be a result of greater remedial efforts in the western area by Texaco in the 1950s.

Type 1 LNAPL from the pipeline release (or possibly the same type of LNAPL from different sources) also migrated to the northwest from the source area near the top of the hill. In the area west and south of the pipeline leak, all three hydrocarbon types are present, indicating mixing from multiple sources/releases. Slightly to the north, there is still evidence of mixing of all three hydrocarbon types, but Type 1 hydrocarbon is more prominent. LNAPL in wells screened in deeper, fractured, competent shale and located in the agricultural field northwest of the former refinery is comprised of unweathered Type 1 hydrocarbon.

Type 2 - Type 2 hydrocarbons are a component of the impacts in the area along the contact between glacial drift and alluvial sediments in the Town of Sunburst, and in the weathered shale in the western and northwestern portion of the former tank farm. A source of Type 2 hydrocarbons has been tentatively identified north of the leaking pipeline area, in the vicinity of sonic borings C and D (Newfields 2008a). This area is not currently impacted by either benzene or TPH, which is not surprising because most wells in the area are dry or have limited groundwater supply. If this area is the source of Type 2 hydrocarbons in the western tank farm and in town, the LNAPL released there probably moved out of the area through open pore space and/or fractures before contacting groundwater. Groundwater gradient and well production rates indicate a minor flow path to the northeast from this source area, and Type 2 hydrocarbon impacts have been identified (in addition to a primary Type 1 component) in several wells on the western side of the drift-clay contact in town (ChevronTexaco ETC 2006 and Newfields 2010a, 2010c, 2012). Type 2 impacts are confined to the western side of that impacted area, and do not extend to wells on the eastern side, nor do they extend into the second impacted area to the east (Figure 7.2-15). It appears that Type 2 hydrocarbons were carried by groundwater flow from their source area(s) on the western side of the hill overlooking the Town of Sunburst to their present distribution along the western side of the drift-clay contact, where the transition to tight clay in the surficial sediments prevented eastward flow. The Type 2 hydrocarbons spread along a north-south axis and mixed with Type 1 hydrocarbons. Type 2 hydrocarbons are generally less widely distributed from their source area than Type 1 hydrocarbons, which may be due to a smaller released volume, or it may be because Type 2 hydrocarbons are naturally less mobile in the environment.

Type 3 - Type 3 hydrocarbons are dispersed widely across the former refinery site in localized, isolated locations. These hydrocarbons are the primary component of impacts in isolated areas around well PA-1 and Tank Berm 10. Additionally, trace amounts of Type 3 hydrocarbon have been identified in widely dispersed but isolated locations within the larger impacted areas in the weathered shale and/or alluvial sediments. Each separate location likely represents a unique source or spill event. Because of their high molecular weight, density, and viscosity, Type 3 hydrocarbons are relatively immobile and have little potential to impact groundwater. An exception is well PA-1, which has a relatively high benzene mole fraction compared with other Type 3 LNAPLs, although it is low compared to Type 1 and 2 LNAPLs at the Facility. Elevated benzene concentrations attributable to Type 3 hydrocarbons from a source near PA-1 occur at well LSSI-21 (Newfields 2008a).

The isolated areas of impacts at SD01-TP-01 and P2RI-53S will be characterized forensically, as the nature of hydrocarbon impacts in uncertain. Based on location alone, it is likely that hydrocarbons at piezometer SD01-TP-01 are similar to the impacted wells in shallow zones slightly to the south; that is, primarily Type 1 with possible minor amounts of Type 2 and/or Type 3 present. Well P2RI-53S is likely impacted by Type 3 hydrocarbons from the nearby, upgradient former wastewater lagoons.

7.2.3 SURFACE WATER AND SEDIMENT

The nature of impacts to surface water and sediment at the Facility is detailed in Chapter 5.0. A total of eight drainage features at the Facility were identified where surface water runoff could occur during precipitation events or periods of snow melt, and those eight drainages were assessed as part of the Phase II RI. From that assessment, it was verified that only one drainage (Surface Drainage 01) at the Facility contained surface water on a more frequent basis other than during precipitation or snow melt events. Surface water in Surface Drainage 01 is present within two areas of the drainage as result of groundwater seepage. As a result, surface water was sampled on a more frequent basis in Surface Drainage 01 during the Phase II RI. Surface water was never present in Surface Drainages 04, 05, or 06 during any of the precipitation or snow melt events when drainage inspections/sampling occurred.

Detected constituents in the surface water samples included a number of inorganics (metals). However, it is assumed that for the metals detected, excessive suspended sediment in the water samples biased high the reported constituent concentrations. In addition to inorganics, organic constituents were detected in one surface water sample collected from Surface Drainage 01, and one surface water sample collected from Surface Drainage 08.

Surface water is not present continuously at the Facility, being intermittently present in surface drainages and the unnamed lake during periods of significant precipitation and/or snow melt. Groundwater seeps are present in Surface Drainage 01, with the amount of discharge variable and directly related to the local groundwater level and the ground freeze/thaw cycle. The aerial extent of surface water in Surface Drainage 01 also varies significantly, in response to seasonal temperature changes and precipitation amount. During hotter, drier periods, the ground surface around the groundwater seep areas is moist, with salt crust/evaporate deposits forming due to high content of total dissolved solids in the evaporating water. During periods of snow melt, frozen ground thawing in the springtime, or rainfall, surface water runoff may be present within extensive portions of the drainage channel and those areas where the channel widens or fans out behind former earthen dams across the drainage.

Overall, impacts to surface water at the Facility and related to the former refinery are confined to the upstream, southern branch of Surface Drainage 01, where seepage of impacted groundwater to the ground surface is occurring. CEMC conducted extensive sample collection/monitoring of surface water in Surface Drainage 01 during 2012, in accordance with the MDEQ-approved work plan (*Data Summary and Proposed Monitoring Activities, Surface Drainage 01*). Based upon that sampling, the extent of surface water with measurable concentrations of dissolved phase hydrocarbon constituents does not extend a significant distance beyond the impacted groundwater seeps.

Soil and sediment samples (sediment being present only in Surface Drainage 01) were also collected from each of the eight drainage features identified at the Facility and assessed during the Phase II RI. Arsenic and cobalt were detected

at a concentration above the direct contact SLs (for soil) in all sediment samples collected, and vanadium was detected at a concentration above the direct contact SL (in soil) in most (93%) of the samples collected. However, site-specific background values in surface soil calculated for these metals, per MDEQ recommended protocol, are above the screening levels. Lead was detected at a concentration above the direct contact SL (and above the site-specific background value calculated) in samples from Surface Drainage 01 and Surface Drainage 04. MDEQ has approved site-specific background values for metals in soil, sediment in Surface Drainage 01, and sediment in the ephemeral lakebed.

Other than the metals discussed above, no constituents were detected at concentrations above the respective MDEQ surface soil RBSL in any of the soil or sediment samples collected from the Facility surface drainages. Some organic constituents (benzene, toluene, xylenes, anthracene, benzo(a)pyrene, and dibenz(a,h) anthracene) were identified in one or more samples at (estimated) concentrations below the respective PQL. One or more of the three EPH fractions were detected at concentrations below the respective MDEQ surface soil RBSL in sediment samples from Surface Drainage 04, Surface Drainage 07, and Surface Drainage 08 (see Figure 5.2-1). Overall, with respect to surface water drainages at the Facility, refinery-related impacts to soil or sediment within surface drainages at the Facility are confined to the following locations:

- Inorganic impacts (primarily lead) to sediment are confined to discrete areas within Surface Drainage 01, and soil within portions of Surface Drainage 04.
- Organic impacts (VOCs and SVOCs) to sediment are confined to the discrete area within Surface Drainage 01 where impacted groundwater discharges to the ground surface.
- Organic impacts (EPH) to soil are confined to discrete areas within Surface Drainage 04, Surface Drainage 07, and Surface Drainage 08.

Soil and sediment samples were collected from the refinery wastewater disposal area and ephemeral lake during completion of delineation of refinery-related impacts east of the BNSF railroad tracks in April 2012. Surface water and sediment samples were also collected from the ephemeral lake during July 2012. Data from surface water samples did not indicate refinery-related impacts to surface water in the lake; however, lead was detected at concentrations above what could be considered background in the sediment samples. As noted in Section 3.8, inspection of available aerial imagery reveals that during the early period of refinery operation, the wastewater treatment area contained a single surface impoundment, with discharge directly to the unnamed lake. At some time after 1941 (but before 1951) the area was bermed, to allow evaporation of discharged wastewater. However, the bermed area was connected by an overflow culvert to the unnamed lake, and aerial photos show discharge of waters from the bermed wastewater disposal area to the unnamed lake.

Additional discussion and results of surface water and sediment sampling conducted at the Facility after December 2012 is presented in Chapter 8.0 of this Report.

7.2.4 VAPOR

Vapor impacts at the Facility result from the volatilization of petroleum hydrocarbons in groundwater, soil, or LNAPL, originating from releases that occurred during operation of the former refinery. The extent of vapor impacts correlates with defined soil and groundwater impacts, including LNAPL distribution. The extent of subsurface impacts for purposes of defining VI investigations was based on information gathered during the 1999-2000 RI and presented in the SSI Report (see Section 1.4.2). The results from that investigation indicated subsurface impacts in soil and groundwater within the residential area of Sunburst appeared to mostly be limited to within half a block (east and north) of the original gasoline release area as defined by Texaco between 1955 and 1957 (see Section 1.4.1). This area, referred to as “the plume” (see Figure 6.2-1), was the area of focus for the VI investigations and evaluation of pathway completion discussed in Section 6.2 of this Report. Occupied structures within and near the plume evaluated during VI investigations are also depicted on Figure 6.2-1.

The distribution of petroleum related constituents in the subsurface is variable in the vadose zone (i.e., non-saturated soils). The shallow silty clays and clays situated beneath Sunburst act as a fractured unit with respect to vapor transport. These clays have a high moisture content, which varies across Sunburst, adding further heterogeneity to vapor transport. The composition of petroleum hydrocarbons measured in the vapor samples collected in deeper portions of the vadose zone is consistent with that of the dissolved phase and/or LNAPL source. Where the vapor phase composition differs from the dissolved phase or LNAPL source, an alternate source of shallow vapors may be present in the immediate vicinity of the nested or near slab monitoring well. The clay and silty clay Quaternary sediments in the shallow subsurface, in combination with higher moisture content, inhibits vapor transport into residences and schools located over the distribution of petroleum hydrocarbons, consistent with the findings provided to MDEQ in the document *Supplemental Investigation Pathway Evaluation and January/February 2010 Additional Vapor Intrusion Investigation Results* (CEMC 2010c).

The result of the pathway completeness evaluation conducted by CEMC was provided in CEMC 2009d and CEMC 2010c. The pathway evaluation conducted by CEMC considered background and alternate sources and biodegradation from the source to indoor air. The MDEQ completed an independent pathway evaluation of the same data set. Based on both Chevron and MDEQ’s interpretation of the data, the pathway was determined to be incomplete at all of the structures sampled with the exception of the structure referred to as SI 03. MDEQ required the installation of a mitigation system at this location. The mitigation system was installed at SI 03 in June 2009.

7.3 POTENTIAL RECEPTORS

An evaluation of potential receptors was provided in the CSM presented in the *2001 Subsurface Investigation Report, Indoor Ambient Air Sampling Program and Human Health Risk Assessments, Former Texaco Sunburst Refinery, Sunburst, Montana* (TRMI 2001a), and again in the 2010 CSM Update Report. The evaluation of potential receptors has been updated based upon investigation data generated subsequent to the submittal of the CSM Update Report and is provided below.

7.3.1 SOIL

Surface soil impacts, limited to lead levels exceeding the RSLs, are present at select properties within the Town of Sunburst as a result of residents having borrowed soils from the tank farm area for use at their property as backfill and for grading. The locations of these impacted properties are presented in Section 3.10. Residents may be exposed to lead-impacted soils through direct contact and/or ingestion of soils. Interim actions to remove lead-impacted soils have been completed at several properties and are underway at the remainder, as discussed in Chapter 8.0.

Both surface and subsurface soil impacts are present at specific locations within the former refinery footprint (see Section 7.2). The majority of these areas are currently owned by CEMC. Potential receptors through either direct contact and/or ingestion of soils would include personnel working on remedial activities at the Facility and, under the trespass scenario, residents of the Town of Sunburst. Exposure to subsurface soils would be limited to excavation and trenching activities that occur for remediation and future municipal purposes. Exposure to subsurface soils could include dermal exposure, ingestion of soils, and inhalation of volatiles.

Future exposure to surface and subsurface soil impacts on CEMC-owned property, which encompasses the majority of the former process area and tank farm, may be limited to commercial/industrial or other restricted use if MDEQ selects institutional controls as part of the final remedy.

In addition to the identified human receptors, flora and fauna have the potential for exposure to constituents in impacted surface and subsurface soils. Fauna direct contact with impacted surface soils present similar exposure concerns as for human direct contact scenarios. Subsurface soils could pose an impact to burrowing animals through direct contact/dermal exposure, ingestion of soils and inhalation of volatiles. Fauna exposure to impacted soils may be greater than for humans in that some controls are more easily applied to humans, e.g. fencing, institutional controls. Contaminant uptake by plants offers slight exposure concerns, primarily as it pertains to garden plants used for human consumption. However, livestock and grazing wildlife could be exposed through uptake by crops and wild grasses. Removal of impacted soils within the Town of Sunburst eliminate direct contact exposures and exposure through

uptake by garden plants. An ecological risk assessment and revised human health risk assessment are under development to address exposure potential for the Facility.

Additional receptors for contaminants in impacted soils include other environmental media, i.e., surface water, sediment, and groundwater. The evaluation conducted to assess whether impacted soils have served as a source of impacts to these media is presented in Section 7.5.

7.3.2 GROUNDWATER

Direct exposure to impacted groundwater may occur at the Facility as a result of excavation and trenching activities that occur in town for both residential and municipal purposes. The potential for exposure will vary depending on depth to groundwater, which has been measured at depths ranging from a few feet below ground surface to more than 25 ft-bgs. Direct exposure routes would include dermal contact and potential inhalation of volatiles.

As previously described, groundwater beneath the Facility and the Town of Sunburst is not used for potable drinking water purposes as a result of high TDS and low transmissivity. Sunburst obtains its potable drinking water and irrigation water from multiple wells located approximately 8 and 14 miles west of town. There are no known wells in Sunburst that use groundwater for domestic purposes.

7.3.3 SURFACE WATER / SEDIMENT

The surface water drainage system and channels at the former refinery portions of the Facility are ephemeral and only flow after periods of significant precipitation or snow melt. Therefore, exposure to surface water is discontinuous. Surface drainages with refinery-related impacts are located wholly on property owned by CEMC, and therefore exposure would be limited to workers at the site, or trespassers. Direct exposure would include dermal contact and ingestion, and for the portion of Surface Drainage 01 where impacted groundwater seeps are present, inhalation of volatiles.

Similar to the surface water drainage system of the former refinery portions of the Facility, the ephemeral lake bed only contains standing water during intermittent periods. Therefore, exposure to surface water is discontinuous, and direct exposure would include dermal contact and ingestion. The lake bed is owned by a mix of private landowners and government entities. While the property is not typically used for recreation or other purposes, access is not explicitly prohibited.

In addition to human receptors, flora and fauna have the potential for exposure via direct contact or ingestion to constituents in impacted surface water and sediments. An ecological risk assessment is under development to address exposure potential for the Facility.

7.3.4 VAPOR

With respect to vapor intrusion, the receptor would be any occupant of a building in Sunburst, if subsurface vapors entered that building. If soil vapors diffuse within the “zone of influence” of a structure without degrading, they will become available to be transported into the structure via advection and convection through drains, cracks, utility entrances, sumps, or other permeable discontinuities in the building floor or basement walls. Wind load on the side of a building, barometric pressure changes, HVAC system operation, or temperature differences can all contribute to building depressurization that can drive advection. Most of these processes are reversible on a short time scale, so vapors generally flow both into and out of buildings under varying conditions. Atmospheric air also enters buildings through doors, windows, and small openings, and the rate of air exchange in buildings typically reduces soil vapor concentrations (Johnson et al. 1999). The rate at which this occurs is dependent on building design, construction, use, maintenance, soil conditions, weather conditions, and similar factors.

7.4 ALTERNATE SOURCES OF IMPACTS IDENTIFIED

Alternate sources of petroleum and non-petroleum related constituents are present in the subsurface as a result of residential and municipal activities at the ground surface that result in contaminants being observed both above and outside of the distribution of refinery-related hydrocarbons. These activities include but are not limited to open burning of household waste (e.g., burn barrels), fuel storage for home heating, open burning of commercial or municipal debris (USEPA 2002a), spills/leaks of fuel to the ground surface (such as that observed proximal to well GW-16 in 2005), chip sealing of streets in town conducted in 2012, street repair work (application of asphalt/oil, observed in September 2013 along portion of 3rd Street South, between 2nd and 3rd Avenues), and road paving/refinishing activities (Mahler 2005, Van Metre et al. 2008). Additionally, there are commercial and industrial activities at the surface that have the potential to create more significant alternate sources.

There are local point sources in Sunburst (including commercial and industrial sources) that could include continuous releases from automobiles, natural gas pipelines, service stations, bulk storage of petroleum hydrocarbons, etc. These sources have the potential to create more significant alternate sources than typically observed from residential uses that can affect deeper portions of the vadose zone, as well as contributing to petroleum hydrocarbons present within the shallow water-bearing zones.

Additionally, naturally occurring levels of inorganic constituents in soil have the potential for contributing to exceedances identified during the Phase II RI (see Background discussion in Section 2.3).

CEMC does not contend that the groundwater impacts present at the Facility are not refinery-caused. The above text serves merely to recognize that sources of petroleum and non-petroleum constituents are common, and present, in the environment at Sunburst.

7.4.1 SOIL

Alternate sources of petroleum contamination could exist in the form of local point sources including continuous releases from automobiles, natural gas and crude oil pipelines, service stations, bulk storage of petroleum hydrocarbons, etc. Potential deposition of metals and SVOCs from combustion of fossil fuels both on the highway (Interstate 15) and/or the BNSF railway property could impact surface soil quality.

As discussed previously, lead was one of the primary constituents of interest during the Phase II RI. Elevated levels of lead have been found in soils at locations in several tank berms, the tank farm, and the wastewater disposal area on the former refinery site, and on some properties within the Town of Sunburst (resulting from the use of former refinery soils as backfill). However, studies have shown that elevated levels of lead, as well as some other metals/inorganics (e.g., Cd, As, Hg) in soil can result from several sources, including:

- Point source emitters, such as smelters, batteries, and mine tailings
- Lead-based paint on exterior surfaces, such as building walls
- Leaded gasoline emissions or spills
- Emissions from highway and railway transport

In rural areas, a common source for elevated levels of lead in residential soils is lead-based paint (USEPA 1998). Two activities attributed to lead-based paint contributing to soil lead levels were the natural chalking and weathering of exterior lead-based paint, and abatement of the paint using scraping or sandblasting techniques without an attached vacuum collection device. Additionally, lead also is also present naturally in soil, though at relatively low levels. According to MDEQ, *Background Concentrations for Inorganics in Soil*, the range is from 11.6 ppm to 34 ppm in Montana.

As with lead, a number of inorganic constituents occur naturally in the environment. For example, MDEQ has established a state-wide background concentration for arsenic of 40 mg/kg (MDEQ 2007). Naturally occurring, or

background, levels of certain inorganic constituents in soil may exceed established screening levels. Inorganic or metals background levels also play an important role in assessing fate and transport between media, particularly if established screening levels vary significantly between media. MDEQ has approved background concentrations for metals in soil, sediment, and surface water at the Facility.

Certain SVOCs (and VOCs) in soils were also constituents of interest during the Phase II RI. The volatile nature of VOCs make it unlikely they would remain in surface soils for extended periods of time. During the investigation, VOCs were more frequently detected in deeper subsurface soils and groundwater, making certain VOCs primary constituents of interest during groundwater and VI investigations. Alternate sources for many VOCs are discussed in detail in Section 7.4.4 and therefore, are not presented here.

Certain SVOCs were detected with sufficient frequency to consider them a primary constituent of concern in soils, in addition to lead. PAHs can be found in some SVOCs, which tend to be more persistent than SVOCs without PAHs. As with lead, there are other, non-refinery sources for SVOCs. Many routine activities have been documented to be sources of SVOCs in soil (USEPA 1999, CCSE 2012). Some of the more common sources include:

- Incomplete combustion of organics (wood, food, plastics, etc.) – Burning of trash or wood, or disposal of charcoal from grills, would result in the presence of PAHs in soils. Smoke can carry particulate PAHs for an extended distance (USEPA 2008a).
- Road paving materials, such as asphalt, coal tar (commonly used in road construction prior to asphalt) (Van Metre, et al. 2008).
- Spillage of hydraulic oil, lube oil, residential fuel oil, and used motor oil – Ground disposal of oils or use in dust control would add PAHs to soil (CCSE 2012).
- Forest/grass fires (more common in areas prone to fire) (USEPA 2008a).
- Deposition of emissions from highway and railway transport (Lopes and Dionne 1998, USEPA 2007, ENVIRON 2002a, ENVIRON 2002b).

Potential impacts from alternate sources were considered when evaluating nature and extent of impacts from the former refinery and in determining Facility boundaries. This would also factor into forthcoming risk assessments associated with the RI/FS process.

7.4.2 GROUNDWATER

As stated previously, local point and area sources have the potential to create alternate sources of impacts that can affect deeper portions of the vadose zone, as well as contributing to petroleum hydrocarbons present within the shallow water-bearing zones. As discussed in Section 7.2.2, shallow impacts in alluvium sediments, and deeper impacts, notably in the upper portion of the weathered shale, can be attributed to releases from the former refinery, notably the 1955 pipeline release. Other releases, not documented by Texaco, are also evident at the former refinery.

As noted, alternate sources (such as asphalt/tar applied during chip sealing of the town streets in 2012) have the *potential* to impact groundwater. CEMC does not contend that groundwater impacts within the Facility are not refinery-related, and does not have any specific data demonstrating groundwater impacts from alternate sources within the Facility boundary. The above text serves merely to recognize that sources of petroleum and non-petroleum constituents are common, and present, in the environment at Sunburst.

7.4.3 SURFACE WATER / SEDIMENT

Alternate sources for impacts to surface water and sediment would be similar to those for surface soil. Additionally, municipal water and sewer systems associated with the Town of Sunburst may contribute to impacts in surface water and sediment in the intermittent lake east of the Facility. Small municipal water distribution systems often contain contaminants such as lead or arsenic that would otherwise be removed in larger municipal systems with greater financial resources to maintain infrastructure, and associated technical capabilities to remove contaminants from source drinking water (USEPA 2013b). Contaminants in water supply systems could transfer to wastewater treatment systems and the sludge produced during the wastewater treatment process.

Small municipal wastewater treatment systems may face similar problems in maintaining infrastructure and treatment capabilities. Contaminants in soils from sources such as those discussed in Section 7.4.1 could infiltrate wastewater collection systems through damaged infrastructure or the normal collection of stormwater runoff. As discussed in Section 4.8, there are infrastructure concerns for both the water supply and sewer systems within the Town of Sunburst (Kadrmaz 2008). In addition, CEMC staff have noted and documented in lakebed inspection forms (with photos) numerous overflows of raw, untreated sewage/effluent at the town's lift station. According to town employees, the lift station's pump system malfunctions/ceases operation frequently, resulting in backup/overflow from the sewer line's manhole cover upstream of the lift station. Untreated sewage/wastewater discharges from the manhole and directly to the ground surface/lakebed.

Additionally, biosolids generated during the wastewater treatment process contain contaminants including metals, pathogens, and organic chemicals. Contaminants may be volatilized, degraded (through biotic and/or abiotic processes), sorbed to sludge, or discharged in the aqueous effluent (Harrison et al. 2006, Kinney et al. 2006). The Town of Sunburst has a permitted effluent discharge from its wastewater treatment facility to the intermittent lake east of the former refinery. The permit requires monitoring the effluent for biochemical oxygen demand and TSS. Per USEPA's Enforcement and Compliance History Online (last accessed July 29, 2013, <http://www.epa-echo.gov/echo/index.html?>), violation letters have been issued to the Town of Sunburst 16 times since 2008. The violations appear to be related in part to exceedances of TSS limits, which in turn suggests contaminants in treatment sludge could be impacting surface water and sediments within the intermittent lake.

7.4.4 VAPOR

Indoor air often contains measurable concentrations of volatile and semi-volatile compounds from household activities, consumer products, building materials, furnishings, and outdoor air sources (NJDEP 2005). Compounds commonly associated with petroleum hydrocarbons are typically found at detectable concentrations in indoor air and outdoor air sources as listed below:

- Operation and storage of automobiles, tools, small engines.
- Storage of home heating oil and natural gas transmission to operate furnaces.
- Storage and use of household cleaners such as carpet cleaners, spot removers, dry cleaning, etc.
- Storage and use of chemicals including strippers, primers, paints, degreasers, lubrication fluids, etc.
- Tobacco smoke, candles, and other combustion sources.
- Air fresheners such as reed diffusers and chemical propelled deodorizers, etc.
- Building materials such as treated woods, carpets, insulation, etc.
- Furnishings including shower curtains, drapes, couches, etc.
- Automotive exhaust, emissions from gas stations, industrial emissions, etc.

Benzene is often the compound that poses the greatest risk in hydrocarbon mixtures. The median background concentration of benzene in indoor air has been established to be above 0.0032 milligrams per cubic meter (mg/m^3) through completion of several independent studies (e.g., USEPA 2011; NYSDOH 2005). Also, MDEQ has published typical indoor air concentrations of VOCs in Montana residences (MDEQ 2012b). The median concentration for benzene in non-smoking Montana residences (not impacted by VI) was $0.00090 \text{ mg}/\text{m}^3$. The median concentration for

benzene in outdoor air in Sunburst was 0.00045 mg/m³, based on the March 2009 and January/February 2010 data. This concentration exceeds the indoor air concentration that would pose a lifetime incremental cancer risk of 1 in 1,000,000 in a residential exposure scenario (0.00031 mg/m³, USEPA 2012). One study found that cigarette use alone accounted for 45 percent of the benzene found in indoor air (Ott and Roberts 1998). Another study found that air exchange between homes and attached garages in which fuels are present, is a major source of benzene and other volatile compounds in indoor air within homes (Batterman et al. 2007). It is very difficult to collect samples and assess indoor air quality without alternate interferences at potentially significant levels.

The air-pressure difference between buildings and the surrounding soil gas fluctuates, so interior sources of hydrocarbon vapors can often result in detectable concentrations in shallow soil gas samples. In addition, shallow releases of hydrocarbons to the subsurface can occur from tools (lawnmowers, chainsaws, trimmers, snow blowers, etc.), automobiles, runoff from roads, and other similar sources. Therefore, it is common to detect low concentrations of hydrocarbon vapors in shallow soil gas and soil samples.

These alternate sources also contribute a variety of chemicals that are not associated with petroleum hydrocarbons from refinery operations. Chlorination of drinking water supplies and refrigeration creates a variety of compounds (e.g., trihalomethanes) that can be detected in the environment. For example, trifluoromethane (a trihalomethane) was detected in every indoor air sampled collected in Sunburst during March 2009 and January/February 2010. Tetrachloroethene is a common solvent used in dry cleaning, spot removers, and many other residential products that is often detected in indoor air at concentrations above risk-based target levels. Tetrachloroethene was detected in 20% of the indoor air samples collected in Sunburst in March 2009 and January/February 2010. The list of potential compounds in consumer products is too extensive to describe completely herein.

7.5 CONCEPTUAL SITE MODEL – SUMMARY

As stated at the beginning of this chapter, a conceptual site model is a summary of the site-specific conditions affecting the distribution, mobility, and fate of chemicals in the environment, and is used to assess and communicate the potential for human health and environmental risks. Data generated by investigation activities conducted between 2010 – 2012 have further advanced the understanding of sources of petroleum and non-petroleum related constituents, physical and chemical transport processes, and receptors. This allows for further refinement of the Facility CSM, last presented in Chapter 5.0 of the CSM Update Report, as follows:

Sources

- Historic releases of petroleum products from former refinery structures (both above ground and below ground) are the source of LNAPL present and migrating from beneath the Facility, most notably in groundwater. Removal of former refinery structures eliminated much of that LNAPL source. Note that while refinery-related sources of LNAPL to the subsurface have been removed, LNAPL remains in discrete locations within the subsurface and can be an ongoing source to groundwater impacts. LNAPL recovery has been conducted since late 2007; discussion of LNAPL recovery efforts is included in Section 8.1 of this Report.
- No wells screened entirely within the alluvial sediments have been found to contain LNAPL. Three general LNAPL types have been identified at monitoring wells screened both into the weathered and competent shale underlying the Facility. Mixtures of variable amounts of each of the three LNAPL types are common:
 - Type 1 – LNAPL of a composition consistent with that of relatively unweathered SRG, also called naphtha. This is the most common LNAPL at the Facility, is the primary component in all of the larger impacted areas, and can be reasonably attributed to the 1955 pipeline leak. Other releases, however, may have occurred during the operational period of the refinery.
 - Type 2 – LNAPL consistent with the chemical characteristics of relatively unweathered kerosene or diesel fuel. It is a component of the impacts in the area along the contact between glacial drift and alluvial sediments in the Town of Sunburst, and in the weathered shale in the western and northwestern portion of the former tank farm. Potential sources, not related to the 1955 pipeline leak, have been identified. Type 2 LNAPL generally is less widely distributed from its source area than Type 1 LNAPL, possibly due to a combination of smaller release volumes and lesser mobility.
 - Type 3 – LNAPL with chemical characteristics similar to those of crude oil, lube oil, gas oil or residuum. It has been found at the Facility in localized, isolated locations. Each separate location likely represents a unique source or spill event. High molecular weight, density, and viscosity, render this LNAPL type relatively immobile with little potential to impact groundwater.
- LNAPL is a continuing source of groundwater and vapor impacts.
- Impacted groundwater discharging to the ground surface at seeps is a source of surface impacts (hyporheic zone and associated sediments) in Surface Drainage 01.
- LNAPL/impacted groundwater is likely a continuing source of impacts to deeper subsurface soils in certain portions of the Facility.
- Removal of impacted soil areas during VCP activities have eliminated much of the source. Residual petroleum and petroleum-related constituents are present in soils but generally are confined to areas within the original footprint

of the former refinery. Soil impacts are generally isolated within the western portion of the tank farm, and somewhat more widespread in the eastern portion of the former refinery. Areas of subsurface soil impacts include primarily the former pipeline corridor in tank farm grid cell G7, VCP excavation areas 05 and 22, and the former railcar loading area.

- The nature of soil impacts is consistent with those constituents typically found at petroleum refineries. The primary refinery-related constituents detected include hydrocarbon fractions, hydrocarbon-related VOCs and SVOCs, and lead.
 - In surface soil, the most commonly detected organic constituents were PAHs and the heavier hydrocarbon fractions. VOCs and VPH fractions were rarely detected in surface soil.
 - In subsurface soil, the most commonly detected organic constituents were also PAHs and the heavier hydrocarbon fractions. VOCs and VPH fractions were detected slightly less frequently than PAHs and EPH.
 - Organic constituents detected in surface soils exceed applicable direct contact or migration to groundwater screening levels in 30% of the samples. In subsurface soils, constituents exceeded screening criteria in fewer than 13% of the samples.
 - With respect to inorganic constituents, lead exceeded the direct contact screening level in 6% of the surface soil samples and 2% of the subsurface soil samples, making it the primary inorganic constituent of concern.
- In general, direct contact SLs were exceeded more often than migration to groundwater screening levels. The locations of direct contact SL exceedances for organic compounds in surface and subsurface soil are shown on Figure 7.5-1A. Figure 7.5-1B shows the locations where direct contact SL exceedances for lead in surface and subsurface soil are present. As shown on Figure 7.5-1A, refinery-related exceedances for organic compounds in surface soil are primarily located in former refinery roadways (asphalt/slag/cinder areas), certain tank berms, and the railcar loading rack areas. In subsurface soils, organic exceedances are primarily confined to a few of the tank berms, the process area, and railcar loading rack areas. Lead is found at concentrations exceeding the direct contact SL primarily in surface soils within certain tank berms, railcar loading rack areas, and the wastewater disposal area. The other area where lead (associated with the former refinery) is found in surface soils is the residential properties in the northwest portion of town, where soil taken from refinery tank berms was used as backfill.
- Alternate sources of petroleum contamination (contributed by others) could exist in the form of local point sources and local area sources including continuous releases from automobiles, natural gas pipelines, service stations, bulk storage of petroleum hydrocarbons, etc. Potential deposition of metals and SVOCs from combustion of fossil fuels both on the highway (Interstate 15) and/or the BNSF railway property could impact surface soil quality. Impacts

not related to refinery operations have been noted in portions of the Facility under private ownership and resulting from activities of the property owner (see Section 3.9).

Additional evaluation, not presented in prior chapters of this Report, was conducted to assess whether soils serve as a continuing source of impacts to groundwater. This evaluation was comprised of several steps, the first being the comparison of surface and subsurface soil locations exceeding MTGW SLs to the extent of groundwater TPH impacts. This comparison is depicted on Figure 7.5-2. The figure was developed under the following premises:

- TPH is the most widely dispersed COI impacting shallow groundwater at the Facility. Using the TPH plume provides the most conservative scenario for evaluating the potential of continuing soil impacts to groundwater.
- The groundwater beneath the Facility meets the criteria for classification as Class IV groundwater as specified in Montana Water Quality Rule 17.30.1006, Section (4).
- Currently, there are no existing beneficial uses of the groundwater beneath the Facility.
- As a Class IV groundwater, MTGW SLs for non-carcinogens do not apply to soils above that groundwater. Figure 7.5-2 therefore depicts only those surface and subsurface locations where COIs classified as carcinogens exceed the MTGW SLs.

Figure 7.5-2 was utilized to identify areas within the TPH plume that are overlain by soils exceeding MTGW SLs, suggesting a possible continuing source to groundwater. The areas identified for further evaluation included: TB10, TB05, TB07, P2RI-4S, P2RI-43, P2RI-6, area in/near TB02 (including PC-G07 & PC-G06), P2RI-45 well cluster, TB30, PA-1, VCP-21, VCP-22, and VCP-23.

The second step in the evaluation process involved a comparative review of depth of soil sample, depth of groundwater, and the COIs that were detected in both soil and groundwater samples collected from the above wells and/or soil areas. Additionally, well installation and soil boring lithology logs were reviewed, along with field forms and other documentation, to assess overall vertical extent of impacts by comparing field screening data/recorded observations in relation to laboratory analytical results. Based on these evaluation criteria, the only areas identified as potentially serving as a continuing source of impacts to groundwater are isolated areas located within TB02. Data more recently collected, in support of the Facility's risk assessments, indicate that a portion of the former process area also may serve as a continuing source of LNAPL/impacts to groundwater. The forthcoming risk assessment reports will present that data and identify those areas in more detail, and those areas will be further evaluated during the FS process.

The above constitute the primary sources of remaining impacts from prior releases at the former refinery. Data and information presented in Chapters 3.0 through 6.0 help define the actual transport mechanisms/exposure pathways and receptors to contaminants from these sources, that in turn define the current CSM for the Facility.

The current, viable contaminant transport mechanisms, exposure pathways and receptors for the Facility are summarized as follows:

- Transport/exposure pathways for vapor impacts resulting from LNAPL/groundwater impacts are addressed in Sections 6.2 and 7.2.4. As stated in those sections, the VI exposure pathway was determined to be incomplete in all but one of the structures investigated. As required by MDEQ, a vapor mitigation system was installed at the residence (identified as “SI03”) determined to have a complete VI pathway.
- Fluctuating level of impacted groundwater is likely re-introducing contaminants to vadose zone soils that are impacted, and with no obvious source of surface/subsurface soil impacts.
- Groundwater impacts are reaching surface areas in the seep located within Surface Drainage 01. Exposure to this water could include dermal exposure, ingestion of water/sediments, and inhalation of volatiles.
- Potential transport of impacted surface soils includes wind deposition, surface water runoff and physical removal of impacted soil from tank berms. Exposure to surface soils could include dermal exposure, ingestion of soils, and inhalation of volatiles.
- Data collected during the Phase II RI indicate there are no impacts in residential areas downwind of impacted tank berms.
- Removal of tank berm soils from the former refinery site to property within town for use as backfill and the extent to which impacts have been identified are discussed in Section 3.10. Interim actions taken to address these impacts have been completed (see Sections 3.10 and 8.2), or ongoing (removal of lead impacted soils still in place beneath alleyway between two residential properties where soils from Tank Berm 34 were used as backfill), and will eliminate the exposure pathway. Since the transport of these soils was not the result of natural processes, the areas impacted were not used to determine Facility boundaries as depicted on Figure 9.1-2. However, CEMC recognizes that by definition, the Facility includes the former refinery site and also includes any area where a hazardous or deleterious substance from the former refinery has been deposited, stored, disposed of, placed, or otherwise come to be located.
- Preliminary field data from the investigation of surface drainages both on and adjacent to the former refinery indicate that no impacts due to surface water runoff from the Facility, in its current condition, are present.

- Sediment sampling in the intermittent lake to the east of the former refinery, conducted during July 2012 in support of the forthcoming Risk Assessment Addendum (RAA), indicate lead is present at levels above background, but below applicable screening levels, in the lake bed. This is likely the result of direct discharges to the lake during operation of the former refinery, compounded by input from alternate sources. This will also be utilized in determining the Facility boundary to the east.
- Subsurface soil impacts that may potentially serve as a continuing source of impacts to groundwater are limited to isolated areas within Tank Berm 02. Data more recently collected, in support of the Facility's risk assessments, indicate that a portion of the former process area also may serve as a continuing source of LNAPL/impacts to groundwater. The forthcoming risk assessment reports will present that data and identify those areas in more detail, and those areas will be further evaluated during the FS process.
- Surface and subsurface soils (defined as 2-10 ft-bgs for the construction worker scenario in the risk assessment process) exceed direct contact SLs in a number of locations, as shown on Figures 7.5-1A and 7.5-1B. Exposure to soils could include dermal exposure, ingestion of soils, and inhalation of volatiles. The extent of the areas that need to be addressed during the FS process will be determined following completion of the RAA.

8.0 INTERIM ACTIONS AND ADDITIONAL STUDIES

This chapter describes completed and ongoing interim actions taken by CEMC to address immediate concerns identified during the Phase II RI, and discusses additional studies to further the understanding of information generated during the Phase II RI. These studies may extend into the forthcoming FS process. Correspondence related to the interim actions and additional studies discussed in this chapter are included in Appendix 8-A.

8.1 INTERIM ACTIONS

Information generated during the Phase II RI and the more recent sampling in support of the RAA, combined with that from prior investigations outlined in Chapter 1.0, allowed for the identification and implementation of interim actions for the Facility and additional studies that would facilitate the FS process. These are discussed in the following sections.

Interim actions are typically designed to address an imminent threat from hazardous or deleterious substances or to further actions that will be consistent with the final remedy for the Facility. Interim actions that have been conducted at the Facility as of the date of this Report are described below.

8.1.1 LNAPL REMOVAL

LNAPL removal activities began December 2007, following the detection of LNAPL in three groundwater monitoring wells (LSSI-9, LSSI-16, and PA-1) and two open-hole sonic soil borings (C-29 and M) installed during the LSSI. In response to a November 26, 2007 request from MDEQ, CEMC developed a work plan, dated December 10, 2007, to monitor and recover LNAPL observed in wells and borings installed during the LSSI (CEMC 2007b). The work plan has undergone subsequent modifications, and LNAPL monitoring and recovery is conducted on a monthly basis in accordance with *Addendum No. 2 to Revised Limited Scoping Investigation Work Plan* (CEMC 2008b). The network of wells/borings was modified as necessary based on information generated during the course of subsequent investigations. Approximately 329 gallons of LNAPL was recovered at the Facility between the beginning of recovery efforts and the start of the Phase II RI in September 2009.

During the Phase II RI (September 2009 to August 2012), approximately 464 gallons of LNAPL was recovered. To date (through September 2013), the site-wide historical total recovery is approximately 940 gallons. Since the inception of the monitoring and recovery program, and continuing through the 2012 calendar year, the results of LNAPL recovery efforts were reported to MDEQ on a monthly basis. Beginning in 2013, as approved by MDEQ in

the December 10, 2012 meeting, CEMC began submitting recovery results letters on a quarterly basis. As indicated in the reports, recovery efforts are conducted multiple times each month.

CEMC has used a variety of LNAPL recovery alternatives including absorbent socks, disposable bailers, passive skimmer units, a solar powered belt skimmer unit, and an assortment of submersible pumps. Selection of the appropriate recovery alternative has been determined through recovery response observations and hydrocarbon baildown/recovery tests.

During the Phase II RI, hydrocarbon baildown/recovery testing was conducted at monitoring wells SDW-5D, SDW-20D, SDW-21D, SDW-24D, SDW-31D, and P2RI-45E. The test at P2RI-45E was conducted as part of the long-term pump test described in Section 4.5.2.2.1 of this Report. During the pump test, LNAPL was observed at well P2RI-45E after approximately two feet of drawdown was achieved, with a maximum thickness of approximately three feet. Over the course of the pump test (90 hours), a total of 8,910 gallons of groundwater and 7.95 gallons of LNAPL was extracted from the well. Two days after completion of the pump test and after the groundwater level returned to +95% pre-test elevation, 0.08 feet of LNAPL was measured in the well. By depressing the groundwater below the suspected hydrocarbon impacted zone, static conditions between the groundwater and residual LNAPL changed, which allowed LNAPL to enter the well screen and resulted in an increase of the amount of LNAPL that could be recovered.

Based on the results of the P2RI-45E test, CEMC attempted to conduct similar tests, i.e., achieve long-term water depression, at monitoring wells SDW-5D and SDW-21D. The purpose of these tests was to determine the viability of sustaining a predetermined water table elevation to induce LNAPL inflow to the well. As presented in the July 6, 2012 letter entitled *June 2012 Groundwater and LNAPL Elevation Measurements and LNAPL Recovery Results, Former Texaco Sunburst Works Refinery, Sunburst, Montana*, monitoring wells SDW-5D and SDW-21D were bailed to dryness multiple times over a 10-day period while gauging fluid levels, amount of hydrocarbon recovered, and the amount of groundwater purged. In total, approximately 42.12 gallons of groundwater were removed from well SDW-5D, which resulted in approximately 0.04 gallons of recovered LNAPL. Approximately 38.27 gallons of groundwater were removed from well SDW-21D, resulting in approximately 0.264 gallons of recovered LNAPL. Although SDW-21D produced significantly more LNAPL than SDW-5D (i.e., the hydrocarbon to water recovery ratio was greater), the quantity recovered at each well was less than one percent of the total fluid recovered from each monitoring well. These results indicate that depressing the water table elevation to induce the inflow of LNAPL at these locations is a poor option for hydrocarbon recovery. CEMC will continue to monitor these wells as part of the routine LNAPL monitoring network and complete LNAPL recovery efforts at each well using an absorbent sock or disposable bailer, in accordance with the MDEQ-approved *Revised LNAPL Recovery Systems Installation and Operation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2012g). If a significant

increase in LNAPL thickness and/or recharge is observed, alternative recovery options will be evaluated and proposed to MDEQ.

In July 2011, and again in May 2012, hydrocarbon baildown/recovery tests were conducted at wells SDW-20D, SDW-24D, and SDW-31D, to determine the sustainable recovery rate and evaluate passive/active recovery systems. The results from both tests indicate that all three monitoring wells recharge at a rate less than 0.1 gpd, which is inadequate for sustaining an active hydrocarbon recovery system. Therefore, as approved by MDEQ, monitoring wells SDW-24D and SDW-31D were fitted with passive recovery absorbent socks to help ensure the maximum amount of product recovery. On the contrary, due to the depth (over 150 ft-bgs), the initial LNAPL thickness (greater than three feet), and the remote location, monitoring well SDW-20D was selected for installation of an active recovery pump system that is operated manually on a routine basis (at least once per month). A detailed description and compilation of applicable information regarding the selected pump system and passive recovery options can be found in the MDEQ-approved October 19, 2012 document entitled *Revised LNAPL Recovery Systems Installation and Operation Work Plan, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2012g).

8.1.2 RESIDENTIAL SOIL REMOVAL

Interim actions were conducted during the 2008 – 2013 timeframe to address soils with refinery-related impacts, taken from tank berm soils and used as backfill on residential properties within the Town of Sunburst. These actions were based on information and data generated during a series of localized investigations that began in 2007 and culminated in a comprehensive residential soils investigation (RSI) performed throughout the Town of Sunburst during 2011 (CEMC 2012b). Section 3.10 of this Report provides a summary of the initial investigations/removal actions and presents the results from the 2011 RSI, which provide the basis for the interim actions initiated in 2012 and completed in 2013. Figure 3.10-1 depicts the properties included in all residential soil investigations, with the exception of the residence located within former Tank Berm 34 which is located outside of the Town of Sunburst grid established for the RSI.

In general, the interim actions involved the removal of residential soils with refinery-related impacts, defined as soils with lead concentrations above the residential screening level of 400 mg/kg, and replacement with clean soils. Property landscaping was repaired or restored, as necessary. The lead impacted soils removed from the residential properties are stored in a temporary stockpile on Chevron-owned, controlled-access property at the Facility. Interim action procedures are detailed in CEMC correspondence to MDEQ entitled “*Soil Sampling Results and Work Plan for Remedial Action, Former Texaco Sunburst Works Refinery, Sunburst, Montana*” (CEMC 2010e), dated June 4, 2010,

and in Chapter 4.0 of the 2011 RSI Work Plan. The properties on which soil removal interim actions have been completed are as follows:

- Residence constructed within former Tank Berm 34 – Soil removal completed in April 2009.
- Properties H1-P2 and H1-P3 – Soil removal completed in November 2010.
- Property I1-P2 – Additional delineation completed December 2010. Lead impacts identified throughout the property and under garage structure. Soil removal, including removal/replacement of garage structure, initiated and completed in 2012.
- Property H1-P1 – Impacts identified throughout property and under garage structure during RSI. Soil removal, including removal/replacement of garage, initiated and completed in 2012.
- Properties H3-P3, I2-P3, and N6-P4 – Properties each had one location with lead concentrations in excess of the residential RSL. Soil excavation at these isolated locations was completed during September 2013.

In addition to the completed actions listed above, soil removal interim action is to be completed at the following location:

- Alleyway between properties H1-P1 and I1-P2. A small area of lead impacted soil remains (likely spillover of backfill soil from the two properties) in the alleyway.

CEMC anticipates completion of the removal of remaining lead impacted soils in the alleyway.

A report (*Residential Soil Interim Actions*) summarizing the soil removal interim actions completed through 2013 is included in Appendix 8-B. The Residential Soil Investigation Summary provides a summary of interim measures and lead impacted soils removal work conducted at residences located within the Town of Sunburst.

8.1.3 SURFACE DRAINAGE 01 FENCING

As noted in Section 5.1.2, dissolved phase hydrocarbon constituents were detected in groundwater and surface water samples collected during early 2012 from an area of Surface Drainage 01 where groundwater discharges to the ground surface. As an interim action, and as required by MDEQ, CEMC installed fencing around identified groundwater seeps and associated surface water within Surface Drainage 01 where exceedance of Montana DEQ-7 standards or Tier 1 RBSLs exist, for purpose of preventing residents, livestock, or other animals from contact with or ingestion of the surface water. CEMC installed this additional fencing, with signage to indicate access is restricted, in July 2012.

8.1.4 DELINEATION OF LEAD IMPACTED SOILS IN TANK BERMS

Via correspondence dated March 2, 2012 and entitled *2012 Project and Site Activities, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (copy included in Appendix 8-A), CEMC outlined activities proposed to be conducted at the Facility during 2012. One proposed activity was additional delineation of tank berm soils with significantly elevated levels of lead, specifically those having the potential to exceed TCLP limits and thereby meet the definition of characteristically hazardous waste.

The ultimate purpose of these activities was to identify a quantity of soils with the greatest potential to serve as continuing source of impacts and that would require disposal at a licensed hazardous waste facility. Related benefits would be a dataset correlating XRF screening values to TCLP analytical results, which then could be used to establish XRF screening levels indicative of lead levels likely to fail TCLP analyses, and delineation of an area that could be a candidate for pilot studies evaluating in-situ treatment of lead-impacted soils.

A work plan letter dated June 1, 2012 to MDEQ outlined the delineation of elevated lead concentration in tank berm soils (see Appendix 8-A). Tank berms that were identified as having elevated levels of lead present include Tank Berms 3, 5, 15, 18, 30, 31, and 32.

Soil screening/sampling was conducted October 8-12, 2012, in these tank berms to better delineate (vertically and horizontally) the areas of elevated lead concentration. In addition to the tank berms, additional sampling and delineation were conducted at ASC08 and ASC11 (areas adjacent to Tank Berms 31 and 18, respectively). The locations of the tank berms and ASC areas assessed are depicted on Figure 8.1-1. Borings were installed at approximately 25-foot intervals within the targeted areas, to a depth sufficient to delineate the vertical extent of elevated lead concentration. Seventy-two locations were screened within the seven tank berms, and eight locations were screened in the two ASC areas. At all locations except one (TB18-E04-DP03), a maximum depth of four ft-bgs was sufficient to complete vertical delineation. Soil samples were screened on 6-inch intervals utilizing a portable XRF analyzer.

In November 2012, additional sampling was conducted in the tank berms. Samples were collected using the methods described Chapter 2.0 and sent to the laboratory for TCLP and total lead analyses. The samples submitted to the laboratory were selected to cover a range of XRF screening results, in an attempt to correlate the XRF lead result, laboratory (total lead) result, and TCLP result. The results for each sample submitted to the laboratory are shown on Figure 8.1-2.

As shown on Figure 8.1-2, XRF results were lower than corresponding laboratory analytical results for the samples. The TCLP analysis result for each sample was above the limit (5.0 mg/L) for lead, indicating that the soils in the areas sampled are characteristically hazardous for lead. Remedial options to address these soils will be assessed by CEMC and proposed to MDEQ. MDEQ will determine the final remedial option(s) in the Facility's Record of Decision.

8.2 ADDITIONAL STUDIES

CEMC outlined activities proposed to be conducted at the Facility during 2012 in a March 2, 2012 document entitled *2012 Project and Site Activities, Former Texaco Sunburst Works Refinery, Sunburst, Montana*. This correspondence contained proposals for additional studies that could further the FS process. Additional studies were proposed (documented in separate correspondence) based on sampling activities initiated to supplement the Phase II RI results and support the risk assessment process. These studies, and their status, are summarized below.

8.2.1 NITRATE APPLICATION TO GROUNDWATER

CEMC conducted a study to evaluate the effectiveness of land application as a delivery mechanism to increase nitrate concentration in groundwater, and evaluate if groundwater concentrations of total BETX (sum of benzene, ethylbenzene, toluene, and total xylenes) and/or TPH can be decreased by stimulating nitrate reduction activity. The study was conducted in portions of the former refinery where shallow groundwater is impacted by hydrocarbon releases.

Two 50 foot by 50 foot study areas were constructed in June 2012, each surrounded by a soil/hay bale berm. Within each study area the vegetation was removed and the ground ripped to approximately 3 ft-bgs. At Study Area #1, containing monitoring well GW-C-47S, 250 pounds of calcium nitrate fertilizer was evenly distributed on the ground surface before approximately 13,800 gallons of potable water was uniformly applied to the surface. At Study Area #2, containing monitoring wells P2RI-45S, P2RI-45D, and P2RI-45E, no calcium nitrate fertilizer was applied, but the same amount of water (approximately 13,800 gallons) was applied uniformly to the ground surface.

As outlined in the MDEQ-approved work plan, dated June 6, 2012, CEMC conducted four sampling events throughout a 90-day period of time (baseline, 30-day, 60-day, and 90-day) to evaluate the nitrate application. The fourth sampling event (90-day sampling event) was conducted during September 2012. Results from the study were presented to MDEQ in a submittal dated December 4, 2012 (*Nitrate Application to Groundwater Study Report*, [CEMC 2012h]). A copy of that submittal is included herein as Appendix 8-C.

Additional sampling has been completed since submittal of the December 4, 2012 document, in order to assess further the effects of the land application. A summary report providing all data collected to assess the nitrate application will be submitted to MDEQ by March 31, 2014.

8.2.2 SOURCE OF IMPACTS AT SURFACE DRAINAGE 01 GROUNDWATER SEEP

The MDEQ-approved work plan for Surface Drainage 01 (CEMC 2012e) included a proposal to investigate the area proximal to shallow well/piezometer SD01-TP-01, where concrete rubble, scrap metal, and other debris (e.g., wood, glass, nails) are present on the ground surface. The area was investigated via shallow test pits and screening of soils with a PID/FID in an attempt to determine whether any materials are present which may be responsible for groundwater impacts in the area.

On October 11, 2012, CEMC installed seven shallow test pits in and around concrete/debris/rubble piles located approximately 100 feet to the east/uphill of piezometer SD01-TP01. The location of SD01-TP01 is depicted on Figure 5.1-2. In addition to test pits, the concrete rubble and other debris were moved aside, to allow visual inspection of what was beneath those materials. Test pits were installed to depths ranging from 3 to 5 ft-bgs. There was no evidence (based on olfactory and visual observations) of hydrocarbon impacted soil within the test pits or beneath the debris piles. Saturated soil and groundwater were observed in several of the test pits. As such, no soil samples were collected for laboratory analysis. All test pits locations were surveyed with a handheld GPS unit.

CEMC also collected groundwater and surface water samples from selected locations within and around Surface Drainage 01, for purpose of determining major ion chemistry of those waters and to assess the source (shallow groundwater or deeper groundwater) of the hydrocarbon impacted groundwater seeps in the drainage. A draft summary of that data was produced and transmitted to MDEQ via email on January 10, 2013. As indicated in the draft data summary, deeper groundwater can be distinguished from shallow groundwater and/or precipitation. The shallow potentiometric surface in the area around Surface Drainage 01 is very near the topography and is likely to rise above the topography during periods of high groundwater level (consistent with the occurrence of the ephemeral groundwater seeps and surface water). The data indicate that the source of the groundwater seeps and surface water in the drainage is the local shallow groundwater and/or precipitation. CEMC will include a presentation and discussion of water quality monitoring data collected from Surface Drainage 01 concurrent with the Facility's forthcoming annual groundwater quality monitoring report (due to be submitted to MDEQ by March 31, 2014).

8.3 BACKGROUND DETERMINATION, INORGANIC CONSTITUENTS

CEMC has completed investigation for determining background concentrations of metals in soil, sediment, and surface water at the Facility.

8.3.1 BACKGROUND SOIL

As discussed in Section 2.3.1.1, determination of background included submittal of a number of proposed data sets and work plans. Proposed background concentrations of metals in soil are reported in the June 3, 2013 document titled *Background Evaluation, Metals Concentrations in Soil, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (CEMC 2013b). This document is provided in Appendix 2-D. The calculated background values are also provided on the Facility soil COI list (Table 2.1-1) and in the soil data summary tables that accompany Chapter 3.0. MDEQ conditionally approved the background values presented in the June 3, 2013 submittal in correspondence dated June 12, 2013.

8.3.2 UNNAMED INTERMITTENT LAKE, SURFACE WATER AND SEDIMENT

As discussed in Section 2.3.1.2, the need for collection of background samples to support the ERA portion of the upcoming RAA for the Facility was discussed during a meeting with MDEQ on May 31, 2012. It was agreed during the meeting that, as part of this effort, background samples would be collected from select surface water and sediment locations within the unnamed intermittent lake located east of the former refinery.

Portions of the lake bed were previously sampled as part of soil investigations (see Section 3.8). Based on those investigations, the lake bed did not exhibit impacts per the established protocol for step-out soil sampling. Therefore, it was deemed appropriate to collect background samples from areas of the lake bed well removed from prior investigation areas.

The majority of background sample locations were in portions of the lake bed located on BLM property. On July 12, 2012, CEMC received permission from BLM to install temporary water level gauges and to collect both surface water and lake sediment samples, in support of the background determination effort. A copy of the BLM letter granting access is included in Appendix 8-A.

A work plan proposing collection of samples for determination of background metals concentrations in surface water and sediment in the unnamed lakebed was first submitted to MDEQ on June 11, 2012 (*Background Sampling Plan, Metals and Polynuclear Aromatic Hydrocarbons (PAHs) Concentrations in Sediment and Surface Water* [CEMC 2012c]). That work plan was revised several times based on input from MDEQ, and a final approach for collection of

background metals data was presented in the January 28, 2013 submittal *Background and Data Gap Sampling Work Plan for Offsite Soils and Surface Water and Sediment in Surface Drainage SD01 and the Lakebed* (CEMC 2013a). That work plan was approved via correspondence dated February 13, 2013. Sediment samples for determination of background concentrations of metals were collected between July 2012 and March 2013. Surface water samples were collected iteratively, between July 2012 and June 2013. Those data have been evaluated and discussed with MDEQ, and proposed background metals concentrations in surface water and sediment were presented in a September 23, 2013 submittal to MDEQ (*Technical Memorandum, Background and Data Gap Sampling Results and Background Evaluation, Metals Concentration in Sediment and Surface Water* [CEMC 2013c]). MDEQ approved the proposed background values in correspondence dated October 3, 2013. A copy of the September 23, 2013 submittal is included as Appendix 8-D.

8.3.3 SURFACE DRAINAGE 01, SURFACE WATER AND SEDIMENT

As discussed in Section 2.3.1.2, the need for collection of background samples to support the ERA portion of the upcoming RAA for the Facility was discussed during a meeting with MDEQ on May 31, 2012. It was agreed during the meeting that, as part of this effort, background samples would be collected from select surface water and sediment locations within Surface Drainage 01.

A work plan proposing collection of samples for determination of background metals concentrations in surface water and sediment in Surface Drainage 01 was first submitted to MDEQ on June 11, 2012 (*Background Sampling Plan, Metals and Polynuclear Aromatic Hydrocarbons (PAHs) Concentrations in Sediment and Surface Water* [CEMC 2012c]). That work plan was revised several times based on input from MDEQ, and a final approach for collection of background metals data was presented in the January 28, 2013 submittal *Background and Data Gap Sampling Work Plan for Offsite Soils and Surface Water and Sediment in Surface Drainage SD01 and the Lakebed* (CEMC 2013a). That work plan was approved via correspondence dated February 13, 2013. Sediment samples for determination of background concentration were collected in July 2012 and March 2013. In an effort to account for temporal variability in surface water metals concentrations, sampling was conducted during three separate events (July 2012, November 2012, and March 2013).

Those data have been evaluated and discussed with MDEQ, and proposed background metals concentrations in surface water and sediment were presented in a September 23, 2013 submittal to MDEQ (*Technical Memorandum, Background and Data Gap Sampling Results and Background Evaluation, Metals Concentration in Sediment and Surface Water* [CEMC 2013c]). MDEQ approved the proposed background values in correspondence dated October 3, 2013. A copy of the September 23, 2013 submittal is included as Appendix 8-D.

8.3.4 PROPOSED STUDIES NOT IMPLEMENTED

Two of the studies proposed in the March 2, 2012 site activities letter, were not initiated during 2012. They are:

- *Small-Scale Pilot Test of Landfarming of Hydrocarbon Impacted Soils* – A decision was made to not pursue this study following detailed discussions with subject matter experts within Chevron’s Energy Technology Company. The proposed study was to involve impacted soils and materials from the Facility’s ASC areas and Tank Berm 18. A review of analytical data and related chromatograms resulted in the conclusion that those soils and materials from these areas would not be amenable to bioremediation through land farming. These conclusions, and the decision to not pursue the study, are documented in correspondence to MDEQ dated June 1, 2012 and entitled *Revised Soil Removal Interim Action Work Plan and Feasibility of Land Farm Pilot Test, Former Texaco Sunburst Works Refinery, Sunburst, Montana* (copy provided in Appendix 8-A).
- *Preliminary Evaluation of Feasibility of Onsite Landfill* – This study was originally planned for 2012 but delayed until completion of interim actions, which would then allow for a better estimate of the volume of material that would potentially be landfilled onsite. This task may be completed during the FS phase of the project.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The primary objective of the Phase II RI was to define the nature and extent of impacts from former refinery operations, establish Facility boundaries, and better define the Facility's CSM. In addition, data collected during the Phase II RI will be used in part to support development of a RAA for the Facility and initiate the FS process. The preceding chapters of this document present the results of investigations conducted to satisfy the requirements of MDEQ's May 16, 2008 SOW for a Phase II RI and the current CSM for the Facility. This chapter presents the overall conclusions from the Phase II RI, and discusses additional studies and a schedule to further the FS process.

9.1 CONCLUSIONS

Investigation activities associated with the Phase II RI were conducted between March 2009 - July 2012 (VI investigations were underway by April 2006 and/or completed prior to final MDEQ approval of the CSM Work Plan and Phase II RI Work Plan). During this timeframe, an extensive number of samples were collected from soil, groundwater, surface water, sediment, and subsurface vapor. Figure 9.1-1 depicts the locations where samples were collected during the Phase II RI. Note that these are only the locations from which samples were collected and submitted for laboratory analysis. The figure does not depict the multiple locations at which field screening was performed (e.g., XRF screening). Nor does the figure depict the number of samples collected at each location. In many instances, more than one sample was collected from the same location over the course of the Phase II RI (e.g., samples collected from a single boring at multiple depth intervals). During the course of the Phase II RI, the following samples were collected:

- A total of 3,275 soil samples consisting of 2,427 environmental samples, 271 blind duplicates, 213 equipment blanks, 1 field blank, and 363 trip blanks were collected between September 2009 and April 2012.
- A total of 628 groundwater samples consisting of 444 environmental samples, 43 blind duplicates, 26 equipment blanks, 23 field blanks, and 92 trip blanks were collected between January 2010 and May 2012.
- A total of 47 sediment samples consisting of 26 environmental samples, 3 blind duplicates, 6 equipment blanks, and 12 trip blanks were collected between February 2010 and August 2010.
- A total of 60 surface water samples consisting of 40 environmental samples, 4 blind duplicates, 2 equipment blanks, and 14 trip blanks were collected between March 2010 and May 2012.
- During the course of VI investigations, covering a five-year period which began in 2006, 564 air/vapor samples were collected from 48 structures and 7 multi-level nested wells.
- More than 16,000 XRF screenings (including duplicates) of soil.

The above numbers do not reflect all the samples and data collected during the timeframe the Phase II RI was underway. Media samples collected as part of routine sampling, confirmation sampling associated with interim actions, or in support of risk assessment activities are not reflected in the above numbers. The numbers also do not reflect additional data or field data gathered during some of the investigation activities performed as part of the Phase II RI, e.g., the southeast diversion ditch (see Section 5.3) and the EM anomaly in the former northwest tank farm area.

The data generated from the sample locations depicted on Figure 9.1-1, in combination with data and information gathered during adjunct investigation activities, were used to determine Facility boundaries. Consistent with the procedures presented throughout the Phase II RI Work Plan, determinations that an area or media was impacted were based on the exceedance of MDEQ RBSLs, USEPA RSLs, MCLs, and/or Montana Numeric Water Quality Standards, depending on the media in question. The data evaluation process for each media is summarized in Chapter 2.0 of this document.

Additionally, the criteria used to direct step-out sampling and determine associated sample density (key components of the investigation process) were based on exceedance of applicable residential screening levels/MDEQ standards. Both are discussed in the media-specific chapters of the Phase II RI Work Plan and summarized in Chapter 6.0 of the Phase II RI Work Plan. As presented in that document, criteria to direct step-out sampling were as follows:

- Residential RSL (400 mg/kg) for lead to 6 ft-bgs
- For surface soil: Residential RBSLs/Residential RSL (if no RBSL)
- For subsurface soil: Step-out if concentration > Residential RBSL/Residential RSL (if no RBSL)
- For metals: Step-out if concentration > Residential RSL (driven by As and Pb)
- For groundwater or surface water: Step out if concentration > DEQ-7 standard

The above criteria were confirmed in MDEQ correspondence dated November 17, 2010, regarding step-out soil sampling locations proposed by CEMC. A copy of this letter is included in Appendix 8-A. Location and density of step-out samples were based, in part, on the understanding that MDEQ will consider areas between an impacted sample location and a non-impacted sample location to be impacted.

The data evaluation procedures (see Chapter 2.0) used to define the media impacts presented in preceding chapters of this Report, expand, and refine the above criteria utilized during the step-out sampling process. Consistent throughout all evaluation procedures is the use of the aforementioned screening levels and/or standards to define impacted areas. Although the term “Facility”, as defined by MDEQ, includes any area where a hazardous or deleterious substance

from the former refinery has been deposited, stored, disposed of, placed, or otherwise come to be located, a number of constituents associated with refinery activities occur naturally in the environment or are ubiquitous in that they are associated with anthropogenic activities other than refining operations. For these reasons, some quantitative methods need to be utilized in defining a “Facility”. Facility boundaries, depicted on Figure 9.1-2, are based on areas that exceed applicable screening levels and/or other MDEQ standards. Using the footprint of original refinery operations as the starting point, the boundary was expanded outward corresponding to exceedances of applicable screening levels and/or MDEQ standards. Facility boundaries are located at the point at which exceedances, regardless of media, were no longer observed. This is consistent with the step-out sampling or delineation process approved by MDEQ in the Phase II RI Work Plan.

An exception to this approach is the method used to define the Facility boundary to the east, based on potential sediment impacts in the intermittent lake bed. Initial investigation and delineation activities involving lake bed sediment utilized the approach summarized in the preceding paragraph (see detailed discussion in Section 3.8). Data collected to support the risk assessment process suggested refinery-related constituents were present at levels greater than established background (see discussions in Section 2.3.1 and Section 5.3), but below applicable screening levels. It was decided to extend the Facility boundary to the east based on sediment impacts exceeding established background levels.

There are two primary reasons for this change in approach. First, sediment differs from soil in that there are more available transport mechanisms at the Facility. As described in Section 7.2.1 of the Phase II RI Report, soil impacts generally are confined to the former refinery property, which is consistent with the general lack of a significant transport mechanism for soil impacts. Historical aerial photographs indicate surface water within the former wastewater treatment area was in direct contact with surface water from the intermittent lake during refinery operations. This provides mechanisms for contaminant transport via both sediment and surface water movement.

Second, the lake bed and SD01 are potential habitat for riparian or aquatic ecological receptors. This habitat occurs infrequently in the vicinity. MDEQ’s risk-based screening criteria for sediment are based on protection of these aquatic ecological receptors (reference MDEQ risk assessment FAQ website). For some constituents (e.g., lead), the MDEQ screening concentration for sediment is at or below background. These background concentrations, or the MDEQ sediment screening level are/will be/have been used to identify the Facility boundary for sediment.

While the lake bed (and SD01) are potential habitat for aquatic receptors, this is a conservative assumption designed to be precautionary and protective. The extent (lateral and temporal) of any actual habitat, and its use by ecological receptors, and any identified risk to those receptors, will be determined through the ecological risk assessment process.

CEMC has worked collaboratively to define the scope and methods to be used in the ERA for the Facility, and an ERA work plan was submitted to MDEQ for review on May 30, 2013. After review and issuance of comments by MDEQ, a revised ERA work plan was submitted on October 11, 2013.

The Facility boundary depicted on Figure 9.1-2 represents the outermost extent of observed impacts. The extent of impacts varies between media, and not all media within all areas of the Facility are impacted. For example, Figure 9.1-2 indicates the Facility boundary extends northward into the Town of Sunburst. That portion of the boundary was defined by the extent of groundwater impacts (see Section 7.2); refinery-related soil impacts do not extend to that same area. Additionally, Facility boundaries as drawn do not denote uniform impacts throughout a specific medium. Extent of media-specific impacts is addressed in preceding chapters of this Report. Moreover, not all impacts within the Facility will require remediation and the extent to which impacted media need to be addressed will be determined, in part, through the risk assessment process. In the future (and with MDEQ approval), the Facility boundary may be modified as supported by analytical data.

In addition to defining the Facility boundary, information and data generated during the Phase II RI were used to develop the following general conclusions:

- The nature of impacts from the former refinery operations and the fate/transport mechanisms for COIs are generally consistent with those reported in prior reports (1990 RI Report [TRC 1990b], 2001 SSI Report [TRMI 2001a] and the 2003 FS Report [CESC 2003]).
- Remedial activities conducted during the VCP effectively removed much of the remaining refinery structures and soil serving as sources of impacts.
 - The area of soils exceeding screening levels represents a relatively small portion of the whole Facility. Using the figures presented in Chapter 3.0, it is estimated the total area of surface and subsurface soil impacts comprises approximately 21 acres. The acreage of the Facility, as presented in Figure 9.1-2, consists of more than 475 acres. Soil impacts exceeding SLs therefore represent less than 5% of the Facility area, based upon this data. Data more recently collected, in support of the Facility's risk assessments, indicate that a portion of the former process area contains soils with significant refinery-related impacts (possibly with constituent concentrations exceeding SLs). The forthcoming risk assessment reports will present that data and identify those areas in more detail, and those areas will be further evaluated during the FS process.
 - Impacted soil with the potential to serve as a continuing source of groundwater impacts appears to be confined to one localized area. This will be further evaluated during the FS process. Data more recently collected, in support of the Facility's risk assessments, indicate that a portion of the former process area also may serve as a

continuing source of LNAPL/impacts to groundwater. The forthcoming risk assessment reports will present that data and identify those areas in more detail, and those areas will be further evaluated during the FS process.

- The extent to which impacted soils present a direct contact exposure concern, and thus the extent to which they need to be addressed during the FS process, will be determined in the RAA.
- Sediment is absent from the smaller surface drainage features at the Facility. As defined by USEPA, sediment is “loose particles of sand, clay, silt, and other substances that settle at the bottom of a body of water.” With the exception of the three larger drainage features at the Facility (Surface Drainage 01, Surface Drainage 02, and Surface Drainage 03), sediment is not present in the surface drainages identified at the Facility and data from “sediment” samples collected from the smaller drainage features (Surface Drainage 04, Surface Drainage 05, Surface Drainage 06, Surface Drainage 07, and Surface Drainage 08) represent soil conditions. The extent to which impacts to soil/sediments pose a concern requiring remediation will be addressed in the RAA, and in consideration of the following:
 - Of the metals detected at concentrations above direct contact SLs (arsenic, cobalt, lead, and vanadium), only lead is considered to be refinery related. Lead was detected above SLs only in Surface Drainages 01 and 04.
- Exceedances of applicable SLs in sediment in the unnamed lake east of the Facility are limited to localized areas immediately east and south/southeast of the former wastewater lagoon. However, as discussed in Chapter 5.0, lead was detected in sediment samples collected from throughout the lake bed (east and west of the interstate highway) at levels greater than established background. The background soil concentrations of three metals (arsenic, cobalt, and vanadium) exceed the RSL, and were detected at concentrations above the RSL in all sediment samples collected.
- Refinery-related impacts to surface water in drainages at the Facility are confined to the upstream, southern branch of Surface Drainage 01, where seepage of impacted groundwater to the ground surface is occurring. Identifying the source of impacts may require further study. The extent to which impacts require remediation will be addressed in the RAA, and in consideration of the following:
 - Surface water is not present continuously at the Facility, being intermittently present in surface drainages and the unnamed playa during periods of significant precipitation and/or snow melt.
 - Only Surface Drainage 01 contains surface water on a more frequent basis, other than during precipitation or snow melt events, where groundwater seeps are present.
 - Inorganic constituents have been detected at concentrations exceeding the MDEQ standards in surface water samples collected from the drainage features. Other than lead, the detections of those inorganic constituents

are attributed to excessive suspended sediment, based on metals concentrations (both total and dissolved) in filtered vs. non-filtered surface water samples.

- Within the “upstream” groundwater seep area of Surface Drainage 01, dissolved phase organic constituents have been detected in the groundwater and the surface water in the immediate vicinity of the seep area.
- The organic constituent benzo(b)fluoranthene was also detected in one sample of surface water collected from Surface Drainage 08.
- Surface water is intermittently/seasonally present in the unnamed playa, namely during periods of significant precipitation and/or snow melt. Data from surface water samples did not indicate refinery-related impacts to surface water in the lake. Refinery-related lead has been found at concentrations above background, but below the EPA RSL, in lake bed sediments east and west of the interstate highway.
- Refinery-related impacts to groundwater are more extensive than those observed in other media, although there are fewer potential receptors for impacted groundwater.
 - Vapor intrusion issues related to impacted groundwater/LNAPL have been limited to one potential receptor, based on investigation results which concluded all VI pathways are incomplete, with one exception.
 - With the possible exception of impacts identified within the Surface Drainage 01 seep, groundwater/LNAPL related impacts are not likely to pose exposure issues at surface conditions.

9.2 RECOMMENDATIONS AND SCHEDULE

A number of documents/projects are currently in progress for the Facility. As noted in an October 3, 2013 letter from MDEQ, additional data collection may be proposed by CEMC in order to refine the background data sets for Surface Drainage 01. MDEQ has stated it will only allow additional data collection to occur prior to submittal of a Feasibility Study Report for the Facility; therefore, completion of additional data collection (if conducted) will be necessary by end of 2014. CEMC is meeting with MDEQ on October 23, 2013 to discuss and move forward the generation of a Feasibility Study work plan, and it is anticipated that data collection related to the Feasibility Study will occur in late spring/early summer 2014.

CEMC submitted a Revised ERA Work Plan on October 11, 2013. MDEQ has stated an intent to issue comments and/or approval of the Revised ERA Work Plan by the first week of November 2013. Upon approval of the Revised ERA Work Plan, CEMC will proceed with completion of the ERA. Data/sample collection currently being completed at the Facility will be incorporated into a draft ERA, submittal of which is anticipated will occur by January 31, 2014.

As noted in a September 30, 2013 letter from MDEQ, the additional data/sample collection currently being conducted at the Facility must be completed in order for MDEQ to complete its required revisions to the draft Human Health Risk Assessment Work Plan. The deadline to resubmit this revised work plan is January 24, 2014.

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TABLES

**TABLE 1.4-1. SUMMARY OF PRIOR INVESTIGATIONS
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Report/Field Activity	Media	Purpose	General Description	Date	Sampling Program
Site Investigation	Groundwater	Delineation of gasoline leak to identify/eliminate source. Recovery of spilled LNAPL.	Identified and repaired leaking pipeline. Delineated LNAPL plume. Recovered 182,448 gallons (est.) of gasoline and impacted groundwater.	1955 - 1957	36 hydrocarbon recovery sumps. 48 hydrocarbon recovery trenches. (Trenches and sumps constructed for both assessment and recovery.)
LNAPL Monitoring Program	Groundwater	Continued LNAPL monitoring.	System reduced to 2 sumps (1957). LNAPL no longer detected. Program discontinued with State approval (1973).	1957 - 1973	Quarterly monitoring through 1967. Periodic monitoring through 1973.
Preliminary Site Assessment & Site History Report (MDHES)		Determination of whether further Facility investigation warranted.	Resulted in USEPA contracting Ecology & Environment, Inc. to conduct further investigation.	1984	
Site Visit and Sampling Event (Ecology & Environment, Inc. under contract to USEPA)	Surface Water, Sludge, Soils	Determination of whether Facility should be placed on National Priorities List.	Characterization of Facility based on visual site inspection and sample analyses (metals only).	1985 - 1986	
Site Inspection and Public Meeting (MDHES)		Definition of path forward.	Resulted in requirement for Facility to perform RI/FS.	1989	
Remedial Investigation	Sludge, Soil, Surface Water, Sediment, Possible ACM	Identification of potential sources.	Investigation to: •Determine nature/extent of released "hazardous substances." •Gather data for future feasibility study, remedial design, and MDHES risk assessment.	1989 - 1990	Groundwater: samples GW-prefix wells (lead and/or VOCs/TPH). Surface water: 4 samples - 3 from "lake"; 1 from drainage ditch. Sediment: 7 samples - same locations as surface water samples, plus 2 additional ditch locations. Soil: 19 samples from Facility and background locations, plus cuttings from 9 boreholes (VOCs). Sludge: 4 samples (metals/TPH, VOCs, BNAs). Potential ACM: 20 samples (soil, insulation, etc.). Ecological: review/identification of flora, fauna, wetlands, historic/cultural resources.
Residential Ambient Air Survey	Vapor	Evaluation of ambient air in residential and school basements.	Conclusion: Detected VOC concentrations met MDEQ action levels.	1991	
Baseline Ecological and Baseline Health Risk Assessments		Ecological and human health risk assessment.	Resulted in MDEQ preliminary Facility remedial action objectives & preliminary remediation goals.	1993	
Voluntary Cleanup Plan Work Plan	Soil, Piping, Waste	Identification and stabilization/removal of potential sources.	Plan for •Soil investigation activities. •Removal of remaining underground piping. General information regarding stabilization of waste and planned construction of onsite, stabilized waste landfills.	1998	
Voluntary Cleanup Plan Remedial Activities	Soil, Piping, Waste	Identification and stabilization/removal of potential sources.	Remediation of ACM areas, residual sludges and associated impacted soils, former wastewater treatment area, identified lead-impacted soils, identified petroleum-impacted soils (based on action levels applicable at that time); removal of subsurface piping.	1999 - 2003	Sampling of soils to guide remediation activities (>1,000 soil samples analyzed for varying lists of analytes during 1999-2001).

**TABLE 1.4-1. SUMMARY OF PRIOR INVESTIGATIONS
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Report/Field Activity	Media	Purpose	General Description	Date	Sampling Program
Remedial Investigation (results described in 2000/2001 Subsurface Investigation Report and 2002/2003 Feasibility Study)	Groundwater, Soil, Vapor	Assessment of relationship between indoor air quality and petroleum-related constituents in soil/groundwater beneath portions of the town of Sunburst. Conduct indoor air sampling during seasonal "worst-case" conditions and collect paired indoor air/sub-slab samples with appropriate detection limits.	Evaluation of soil and groundwater conditions, as well as indoor air in schools, public buildings, and residences. Focused on BTEX constituents. Risk assessment based on indoor air BTEX results. Study area: original 1955 plume and vicinity.	1999 - 2000	Electromagnetic site survey. Installation of permanent and temporary monitoring wells. Analysis of soils, well cuttings, and groundwater samples. Analysis of drinking water samples from residences. Indoor air monitoring at 2 schools. Indoor air monitoring at 14 residences.
Feasibility Study Report	Groundwater, Soil	Identification of preferred alternative(s) for remediation (1955 plume area).	Presented maps and cross sections prepared utilizing results of RI soil and groundwater investigation. Proposed MNA as the preferred cleanup method for dissolved constituent plume. Subsequently, MDEQ identified MNA as preferred cleanup method.	2002, revised 2003	(utilized data collected during RI)
Review of SSI Air Sampling (Applied Measurement Science under contract to MDEQ)	Vapor	Evaluation of indoor air human health risk assessment in SSI Report.	Based on results, MDEQ required repeated indoor air sampling to assess potential subsurface vapor intrusion of additional constituents. Evaluation of potential additional approaches to soil/groundwater treatment (SVE, MPE, bioventing, etc.).	2003 - 2004	(evaluation of data from SSI Report)
Limited Scoping Subsurface Investigation: Work Plan, Addendum, and Field Work	Groundwater, LNAPL, Soil	Characterization of impacts to soil and groundwater not characterized in previous investigations, with a focus on property located south of the town of Sunburst and potentially impacted by the 1955 gasoline released.	Soil and groundwater samples collected/analyzed in a phased approach; geophysical/hydrophysical logging conducted to better characterize the subsurface including fractured shale; hydrocarbon forensics investigations initiated to better understand possible source(s) of observed impacts.	2005 - 2007	Well construction (44 LSSI-prefix wells). Analysis of groundwater samples (50 locations). Installation of 21 deeper sonic soil borings. Analysis of 82 soil samples. Geophysical/hydrophysical logging of sonic borings. Analysis of LNAPL and groundwater samples (hydrocarbon forensics).
Supplemental Multi-Phase Extraction Pilot Test (Work Plan and Report)	Groundwater, Soil	Evaluation of effectiveness of MPE.	Testing of MPE pilot systems; recommendations regarding future use of MPE systems.	2005 - 2008	System pilot testing at 2 locations.
Supplemental Investigation Work Plan (with associated revisions and addenda)	Vapor	Further evaluation of the vapor intrusion pathway, including an expanded project area, per MDEQ requirements.	Proposed •Collection of groundwater data to evaluate whether measured soil gas concentrations are consistent with dissolved phase constituent concentrations. •Shallow soil gas sampling. •Additional soil assessment. •Further evaluation of vapor intrusion pathway.	2005 - 2006	(see below)

**TABLE 1.4-1. SUMMARY OF PRIOR INVESTIGATIONS
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Report/Field Activity	Media	Purpose	General Description	Date	Sampling Program
Additional Vapor Intrusion Investigation; Supplemental Investigation Interim Report; and Vapor Intrusion Sampling and Analysis Plan	Vapor	Expand indoor air investigation to satisfy the requirements of the OSWER Draft VI Guidance and to provide sufficient information to determine whether vapor intrusion pathway is complete.	Presented results of investigations proposed in the SI Work Plan (as revised and amended). SAP provides interpretation of the vapor-related sampling results from May 2006 through March 2009.	2006 – 2010	Installation of near-slab soil gas monitoring wells (27 residences and a church; SI-prefix), Installation of multi-level nested soil gas monitoring wells and collection of soil gas samples at incremental depths (7 SIVW-prefix wells). Collection and analysis of 17 core samples during drilling of soil gas wells (geotechnical analysis) Sampling of indoor air (40 locations; adjacent to SI-prefix soil gas wells). Installation of sub-slab vapor monitoring probes (26 locations). Collection of crawlspace air samples (24 locations). Collection of "deep" soil gas probe samples (4 residences). Collection of outdoor ambient air samples on each day that near-slab and nested well vapor samples were collected (2 samples daily). Installation and sampling of 1 groundwater monitoring well. Collection and analysis of samples from soil borings in areas surrounding 2 residences (17 borings). Resample activities at 30 locations. Included installation of sub-slab crawlspaces and corresponding soil vapor samples at three locations.
Phase II Remedial Investigation	Groundwater, Surface Water, Sediment, Soil	The purpose of the Phase II Remedial Investigation was to define the nature and extent of impacts from the former refinery, i.e., to determine Facility boundaries.	Phase II Remedial Investigation of remaining areas of potential contamination (soil, air, surface water, or groundwater); data collection to support risk assessment and identification of appropriate remedies.	2009 - 2012	In order to define extent of the Facility, samples of soil, sediment, groundwater, and surface water have been collected and analyzed from throughout the former refinery and the Town of Sunburst
Quarterly Groundwater Monitoring	Groundwater	Long-term documentation of groundwater conditions; evaluation of temporal trends in groundwater quality/elevation.	Quarterly groundwater elevation gauging and sample collection/analysis at a network typically consisting of approximately 18 monitoring wells.	on-going	
Monthly LNAPL Monitoring	Groundwater, LNAPL	Delineation of LNAPL. Evaluation of temporal trends.	Monthly gauging of groundwater and LNAPL elevations in select wells; LNAPL baildown tests; LNAPL recovery system operation. Quarterly reporting of results to MDEQ. Well network based on results of groundwater gauging within a larger network of monitoring wells (i.e., if LNAPL is discovered in a well, typically that well is proposed for inclusion in the monthly LNAPL monitoring program).	on-going	

Notes:

ACM - asbestos containing materials
 BNA - base-neutral acid-extractable compounds
 BTEX - benzene, toluene, ethylbenzene, xylenes
 est. - estimated
 FS - Feasibility Study
 LNAPL - light non-aqueous phase liquid
 LSSI - Limited Scoping Subsurface Investigation
 MDEQ - Montana Department of Environmental Quality
 MDHES - Montana Department of Health and Environmental Sciences (precursor agency to the Montana Department of Environmental Quality)
 MNA - monitored natural attenuation
 MPE - multi-phase extraction
 OSWER - USEPA Office of Solid Waste and Emergency Response
 RI - Remedial Investigation
 SAP - Sampling and Analysis Plan
 SSI - Subsurface Investigation
 SVE - soil vapor extraction
 TPH - total petroleum hydrocarbons
 USEPA - United States Environmental Protection Agency
 VOCs - volatile organic compounds

TABLE 2.1-1. CONSTITUENTS OF INTEREST (COI) LIST FOR SOIL AND ASSOCIATED SCREENING LEVELS
 PHASE II REMEDIAL INVESTIGATION REPORT
 FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Method	Surface Soil (0 - 2 ft-bgs)		Subsurface Soil (deeper than 2 ft-bgs)		Site-Specific Background Values ² (mg/kg)
			Direct Contact SL (Residential) (mg/kg)	Migration to Groundwater SL (mg/kg)	Direct Contact SL (Excavation) (mg/kg)	Migration to Groundwater SL (mg/kg)	
Antimony, Total	n	6010	3.1	2.7	3.1	2.7	0.368
Arsenic, Total	c	6010/6020	0.61	2.9	0.61	2.9	25.1
Barium, Total	n	6010	1,500	414	1,500	414	392
Beryllium, Total	n	6010	16	32	16	32	0.817
Cadmium, Total	n	6010	7	3.8	7	3.8	1.17
Chromium, Total	n	6010	12,000	1,800,000	12,000	1,800,000	30.8
Cobalt, Total	n	6010	2.3	2.3	2.3	2.3	9.13
Copper, Total	n	6010	310	460	310	460	26.6
Cyanide, Total (solid)	n	9012A	4.7	20	4.7	20	NA
Lead, Total	L*	6010	400	140	400	140	30.2
Mercury, Total	n	6010	2.3	NA	2.3	NA	0.0837
Nickel, Total	n	6010	150	147	150	147	32.6
Selenium, Total	n	6010	39	2.6	39	2.6	2.09
Silver, Total	n	6010	39	6	39	6	0.168
Vanadium, Total	n	6010	39	780	39	780	63.9
Zinc, Total	n	6010	2,300	2,900	2,300	2,900	119
Volatile Organic Compounds							
Benzene	c	8260	1	0.04	200	0.04	NA
2-Butanone	n	8260	2,800	40	2,800	40	NA
n-Butylbenzene	n	8260	390	2.5	390	2.5	NA
sec-Butylbenzene	n	8260	780	4.6	780	4.6	NA
tert-Butylbenzene	n	8260	780	1.1	780	1.1	NA
Carbon Disulfide	n	8260	82	2.1	82	2.1	NA
Chlorobenzene	n	8260	29	0.68	29	0.68	NA
Chloroform	c	8260	0.29	0.200	0.29	0.2	NA
Cyclohexane	n	8260	700	130	700	130	NA
1,2-Dibromoethane	c	8260	0.04	0.00002	7	0.00002	NA
1,1-Dichloroethane	c	8260	3.3	0.0068	3.3	0.0068	NA
1,2-Dichloroethane	c	8260	0.5	0.01	104	0.01	NA
Ethylbenzene	c	8260	6	10	1,000	10	NA
Hexane	n	8260	57	18	57	18	NA
Isopropylbenzene	n	8260	210	6.4	210	6.4	NA
MTBE	c	8260	40	0.08	8,000	0.08	NA
n-Propylbenzene	n	8260	340	9.9	340	9.9	NA
Styrene	n	8260	630	1.1	630	1.1	NA
Tetrachloroethene	c	8260	8.6	0.023	8.6	0.023	NA
Toluene	n	8260	600	10	5,000	10	NA
1,1,1-Trichloroethane	n	8260	870	0.7	870	0.7	NA
Trichloroethene	c	8260	0.44	0.018	0.44	0.018	NA
1,2,4-Trimethylbenzene	n	8260	6.2	0.21	6.2	0.21	NA
1,3,5-Trimethylbenzene	n	8260	78	1.2	78	1.2	NA
m,p-Xylene	n	8260	59	94.74	59	94.74	NA
o-Xylene	n	8260	69	100	69	100	NA
Xylenes, Total	n	8260	70	200	600	200	NA

TABLE 2.1-1. CONSTITUENTS OF INTEREST (COI) LIST FOR SOIL AND ASSOCIATED SCREENING LEVELS
 PHASE II REMEDIAL INVESTIGATION REPORT
 FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA

Inorganic Constituents Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Method	Surface Soil (0 - 2 ft-bgs)		Subsurface Soil (deeper than 2 ft-bgs)		Site-Specific Background Values ² (mg/kg)
			Direct Contact SL (Residential) (mg/kg)	Migration to Groundwater SL (mg/kg)	Direct Contact SL (Excavation) (mg/kg)	Migration to Groundwater SL (mg/kg)	
Acenaphthene	n	8270	400	200	4,000	200	NA
Anthracene	n	8270	2,000	4,000	20,000	4,000	NA
Benzo(a)anthracene	c	8270	0.2	10	50	10	NA
Benzo(a)pyrene	c	8270	0.02	4	5	4	NA
Benzo(b)fluoranthene	c	8270	0.2	50	50	50	NA
Benzo(k)fluoranthene	c	8270	2	500	500	500	NA
Bis(2-ethylhexyl)phthalate	c	8270	35	14	35	14	NA
Chrysene	c	8270	20	2,000	5,000	2,000	NA
Dibenz(a,h)acridine	--	8270	NA	NA	NA	NA	NA
Dibenzo(a,h)anthracene	c	8270	0.02	7	5	7	NA
1,2-Dichlorobenzene	n	8270	190	5.8	190	5.8	NA
1,3-Dichlorobenzene	--	8270	NA	NA	NA	NA	NA
1,4-Dichlorobenzene	c	8270	2.4	0.72	2.4	0.72	NA
Diethylphthalate	n	8270	4,900	72.64	4,900	72.64	NA
2,4-Dimethylphenol	n	8270	120	4.5	120	4.5	NA
Dimethylphthalate	--	8270	NA	NA	NA	NA	NA
Di-n-butylphthalate	n	8270	610	50.75	610	50.75	NA
2,4-Dinitrophenol	n	8270	12	0.782	12	0.782	NA
1,4-Dioxane	c	8270	4.9	0.0014	4.9	0.0014	NA
Fluoranthene	n	8270	300	500	2,000	500	NA
Fluorene	n	8270	300	600	2,000	600	NA
Indene	--	8270	NA	NA	NA	NA	NA
Indeno(1,2,3-cd)pyrene	c	8270	0.2	100	50	100	NA
Tetraethyl Lead	n	8270	0.00061	0.000035	0.00061	0.000035	NA
1-Methylnaphthalene	c	8270	16	0.051	16	0.051	NA
2-Methylnaphthalene	n	8270	23	4.4	23	4.4	NA
2-Methylphenol	n	8270	310	5.8	310	5.8	NA
4-Methylphenol	n	8270	610	44	610	44	NA
Naphthalene	n	8270	4	9	200	9	NA
4-Nitrophenol	--	8270	NA	NA	NA	NA	NA
Phenanthrene	--	8270	NA	NA	NA	NA	NA
Phenol	n	8270	1,800	4.73	1,800	4.73	NA
Pyrene	c	8270	200	4,000	2,000	4,000	NA
Pyridine	n	8270	7.8	0.053	7.8	0.053	NA
Quinoline	c	8270	0.16	0.00068	0.16	0.00068	NA
Thiophenol	n	8270	7.8	0.086	7.8	0.086	NA

TABLE 2.1-1. CONSTITUENTS OF INTEREST (COI) LIST FOR SOIL AND ASSOCIATED SCREENING LEVELS
 PHASE II REMEDIAL INVESTIGATION REPORT
 FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Method	Surface Soil (0 - 2 ft-bgs)		Subsurface Soil (deeper than 2 ft-bgs)		Site-Specific Background Values ² (mg/kg)	
			Direct Contact SL (Residential) (mg/kg)	Migration to Groundwater SL (mg/kg)	Direct Contact SL (Excavation) (mg/kg)	Migration to Groundwater SL (mg/kg)		
Carbon Fractions								
Total Petroleum Hydrocarbons (VPH)								
C5-C8, Aliphatic	n	MADEP	60	200	500	200	NA	
C9-C10, Aromatic	n	MADEP	100	100	1,000	100	NA	
C9-C12, Aliphatic	n	MADEP	100	10,000	1,000	10,000	NA	
Total Extractable Hydrocarbons (EPH)								
C9-C18, Aliphatic	n	MADEP	200	50,000	2,000	50,000	NA	
C11-C22, Aromatic	n	MADEP	500	400	4,000	400	NA	
C19-C36, Aliphatic	n	MADEP	20,000	NA	100,000	NA	NA	
Total Extractable Hydrocarbons	n	MADEP	analyzed for individual EPH fractions if result > 200 mg/kg					

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "-" indicates constituent not included in classification system. "L" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

ft-bgs - feet below ground surface

mg/kg - milligrams per kilogram

NA - not applicable or not available

SL - screening level

~~font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

MADEP - Massachusetts Department of Environmental Protection

TABLE 2.1-2. CONSTITUENTS OF INTEREST (COI) LIST FOR WATER AND ASSOCIATED SCREENING LEVELS
 PHASE II REMEDIAL INVESTIGATION REPORT
 FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA

Constituent ¹	Method	Units	LLI MDL	LLI PQL	MDEQ Circular 7	MCLs (40 CFR)	Tier 1 Groundwater RBSLs and Standards	RSL MCL	RSL Tapwater ²
Volatile Organic Compounds									
1,1,1-Trichloroethane	8260	µg/L	0.1	0.5	200	200	--	200	7,500
1,1-Dichloroethane	8260	µg/L	0.1	0.5	--	--	--	--	2.4
1,2-Dichloroethane	8260	µg/L	0.1	0.5	4	5	4	5	0.15
1,2-Dibromoethane (EDB)*	8260	µg/L	0.1	0.5	0.004	--	0.004	0.05	0.0065
1,2,4-Trimethylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	15
1,3,5-Trimethylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	87
2-Butanone	8260	µg/L	1	5	--	--	--	--	4,900
1,3-Butadiene*	8260	µg/L	1	5	--	--	--	--	0.016
Benzene	8260	µg/L	0.1	0.5	5	5	5	5	0.39
n-Butylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	780
sec-Butylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	1600
tert-Butylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	510
Carbon Disulfide	8260	µg/L	0.4	0.5	--	--	--	--	720
Chlorobenzene	8260	µg/L	0.1	0.5	100	--	--	100	72
Chloroform	8260	µg/L	0.1	0.5	70	--	--	80	0.19
Cyclohexane	8260	µg/L	0.1	0.5	--	--	--	--	13,000
Ethylbenzene	8260	µg/L	0.1	0.5	700	700	700	700	1.3
n-Hexane	8260	µg/L	0.1	0.5	--	--	--	--	250
Methyl Tertiary Butyl Ether	8260	µg/L	0.1	0.5	30	--	30	--	12
Isopropylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	390
n-Propylbenzene	8260	µg/L	0.1	0.5	--	--	--	--	530
Styrene	8260	µg/L	0.1	0.5	100	100	--	100	1,100
Tetrachloroethene	8260	µg/L	0.1	0.5	5	5	--	5	9.7
Toluene	8260	µg/L	0.1	0.5	1,000	1,000	1,000	1,000	860
Trichloroethene	8260	µg/L	0.1	0.5	5	5	--	5	0.44
Xylene (m,p, o and Total)	8260	µg/L	0.1	0.5	10,000	10,000	10,000	10,000	190
Semi-volatile Organic Compounds									
1,2-Dichlorobenzene	8270	µg/L	1	5	600	--	--	600	280
1,3-Dichlorobenzene	8270	µg/L	1	5	600	--	--	--	--
1,4-Dichlorobenzene	8270	µg/L	1	5	75	--	--	75	0.42
1,4-Dioxane	8270	µg/L	1	5	--	--	--	--	0.67
1-Methylnaphthalene	8270	µg/L	1	5	--	--	--	--	0.97
2-Methylnaphthalene	8270	µg/L	1	5	--	--	--	--	27
2,4-Dinitrophenol	8270	µg/L	20	60	69	--	--	--	30
2,4-Dimethylphenol	8270	µg/L	3	10	380	--	--	--	270
2-Methylphenol	8270	µg/L	1	5	--	--	--	--	720
4-Methylphenol	8270	µg/L	2	5	--	--	--	--	1400
4-Nitrophenol	8270	µg/L	10	30	60	--	--	--	--
Acenaphthene	8270	µg/L	1	5	670	--	670	--	400
Anthracene	8270	µg/L	1	5	2,100	--	2,100	--	1,300
Benzenethiol (Thiophenol)	8270	µg/L	5	15	--	--	--	--	13
Benzo(a)anthracene	8270	µg/L	1	5	0.5	--	0.5	--	0.029
Benzo(a)pyrene	8270	µg/L	1	5	0.05	0.2	0.05	0.2	0.0029
Benzo(b)fluoranthene	8270	µg/L	1	5	0.5	--	0.5	--	0.029
Benzo(k)fluoranthene	8270	µg/L	1	5	5	--	5	--	0.29
bis(2-Ethylhexyl)phthalate	8270	µg/L	2	5	6	6	--	6	4.8
Chrysene	8270	µg/L	1	5	50	--	50	--	2.9
Dibenz(a,h)acridine	8270	µg/L	1	5	--	--	--	--	--
Dibenz(a,h)anthracene	8270	µg/L	1	5	0.05	--	0.05	--	0.0029
Diethylphthalate	8270	µg/L	2	5	17,000	--	--	--	11,000
Dimethylphthalate	8270	µg/L	2	5	270,000	--	--	--	--
Di-n-butylphthalate	8270	µg/L	2	5	2000	--	--	--	670
Fluoranthene	8270	µg/L	1	5	130	--	130	--	630
Fluorene	8270	µg/L	1	5	1,100	--	1,100	--	220
Indene	8270	µg/L	1	5	--	--	--	--	--
Indeno(1,2,3-cd)pyrene	8270	µg/L	1	5	0.5	--	0.5	--	0.029
Naphthalene	8270	µg/L	1	5	100	--	100	--	0.14
Phenanthrene	8270	µg/L	1	5	--	--	--	--	--
Phenol	8270	µg/L	1	5	300	--	--	--	4,500

**TABLE 2.1-2. CONSTITUENTS OF INTEREST (COI) LIST FOR WATER AND ASSOCIATED SCREENING LEVELS
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Constituent ¹	Method	Units	LLI MDL	LLI PQL	MDEQ Circular 7	MCLs (40 CFR)	Tier 1 Groundwater RBSLs and Standards	RSL MCL	RSL Tapwater ²
Semi-volatile Organic Compounds (continued)									
Pyrene	8270	µg/L	1	5	830	--	830	--	87
Pyridine	8270	µg/L	2	5	--	--	--	--	15
Quinoline*	8270	µg/L	1	5	--	--	--	--	0.021
Semi-volatile Organic Compounds - SIM**									
1-Methylnaphthalene	8270-SIM	µg/L	0.01	0.05	--	--	--	--	0.97
Benzo(a)anthracene	8270-SIM	µg/L	0.01	0.05	0.5	--	0.5	--	0.029
Benzo(a)pyrene	8270-SIM	µg/L	0.01	0.05	0.05	0.2	0.05	0.2	0.0029
Benzo(b)fluoranthene	8270-SIM	µg/L	0.01	0.05	0.5	--	0.5	--	0.029
Dibenz(a,h)anthracene	8270-SIM	µg/L	0.01	0.05	0.05	--	0.05	--	0.0029
Indeno(1,2,3-cd)pyrene	8270-SIM	µg/L	0.01	0.05	0.5	--	0.5	--	0.029
Naphthalene	8270-SIM	µg/L	0.01	0.05	100	--	100	--	0.14
Metals									
Barium	6010	mg/L	0.00062	0.005	1	2	--	2	2.9
Cadmium	6010	mg/L	0.002	0.005	0.005	0.005	--	0.005	0.0069
Chromium	6010	mg/L	0.034	0.015	0.1	0.1	--	0.1	--
Cobalt	6010	mg/L	0.0021	0.005	--	--	--	--	0.0047
Copper	6010	mg/L	0.0022	0.003	1.3	--	--	1.3	0.62
Lead	6010	mg/L	0.00685	0.015	0.015	--	--	0.015	--
Mercury	7471	mg/L	5.6E-05	0.0002	0.002	0.002	--	0.002	0.00063
Vanadium	6010	mg/L	0.0025	0.005	--	--	--	--	0.063
Zinc	6010	mg/L	0.00811	0.02	2	--	--	--	4.7
Antimony	6020	mg/L	0.0003	0.001	0.006	0.006	--	0.006	0.006
Arsenic	6020	mg/L	0.0095	0.002	0.01	0.01	--	0.01	0.000045
Beryllium	6020	mg/L	0.00013	0.0005	0.004	0.004	--	0.004	0.016
Nickel	6020	mg/L	0.0005	0.002	0.1	--	--	--	0.3
Selenium	6020	mg/L	0.00099	0.002	0.05	0.05	--	0.05	0.078
Silver	6020	mg/L	0.00008	0.0005	0.1	--	--	--	0.071
Cyanide									
Total Cyanide (solid)	9012A	mg/L	0.005	0.01	0.2	0.2	--	0.2	0.0014
Tetraethyl Lead									
Tetraethyl Lead	8270	µg/L	2	5	--	--	--	--	0.00099
Total Petroleum Hydrocarbons (VPH)									
C5-C8 Aliphatics	MADEP VPH	µg/L	50	100	--	--	700*	--	--
C9-C12 Aliphatics	MADEP VPH	µg/L	20	100	--	--	1000*	--	--
C9-C10 Aromatics	MADEP VPH	µg/L	20	100	--	--	1000*	--	--
Total Extractable Hydrocarbons (EPH)									
C9-C18 Aliphatics	MADEP EPH	µg/L	30	30	--	--	1000*	--	--
C19-C36 Aliphatics	MADEP EPH	µg/L	50	50	--	--	1000*	--	--
C11-C22 Aromatics	MADEP EPH	µg/L	40	40	--	--	1000*	--	--

Notes:

¹ - This comprehensive analyte list may be reduced as project progresses, based on sample analytical data, and with MDEQ review/approval.

² - These values will only be used as a screening level if there are no DEQ-7 standards, RBSL or MCL for the compound.

LLI - Lancaster Laboratories, Incorporated

MDL - method detection limit

LOQ - limit of quantification

RSL - regional screening levels (USEPA, 2013). (RSLs). <http://www.epa.gov/region09/superfund/prg/>. May 2013)

MDEQ Circular 7 - Montana Department of Environmental Quality (MDEQ), 2012. Circular DEQ-7, Montana Numeric Water Quality Standards. October 2012.

MCL - maximum cleanup level

µg/L - micrograms per liter

-- - information not available

mg/L - milligrams per liter

* - Analyte MDL/LOQ is higher than the screening criteria

** - Select Ion Mode (SIM) analysis will be performed on a sample by sample basis if necessary to achieve the screening criteria

MADEP - Massachusetts Department of Environmental Protection

³ - MDEQ RBSL (from Montana Tier I Risk-Based Corrective Action Guidance for Petroleum Releases, September 2009)

VPH - volatile petroleum hydrocarbons

EPH - extractable petroleum hydrocarbons

**TABLE 2.1-3. SAMPLE NAMING CONVENTION
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Task	Naming Convention (Examples)	Comments
SOIL INVESTIGATION ACTIVITIES		
Former Pipeline Corridors		
Pipeline Corridor	PC-A01-DP01	Pipeline Corridor direct push sample.
Pipeline Corridor Step-Outs based on P2RI WP	PCS1-Q12-DP01	Pipeline Corridor direct push sample. "S1" step-outs based on P2RI Work Plan.
Tank Berm/Tank Farm Soils		
Tank Farm Soil	TF-D02-SS01	Tank Farm samples. Surface soil samples collected.
Tank Berm Soil	TB01-A02-DP01	Tank Berm samples. Surface and subsurface samples collected using direct push methods.
Tank Farm Soil Step-Outs	TFS1-D02-SS01 or TFS2- G07-SS01	Tank Farm/Berm step-outs. Most Tank Berm step-outs were located outside of Tank Berms. A 300 X 300' grid cell sample method was used and incorporated into sample name. Table 3-1 and 3-2 reference the parent IDs associated with TFS1 and TFS2 samples. "S1" was used instead of a continuing sequence since the WP called for step-outs from specific samples/areas. "S2" step-outs are based on lab data.
Tank Berm Soil Step-Outs		
Asphalt/Cinder/Slag Areas		
ASC Soil Step-Outs	ASC01-SS01(1.5-2)	Naming convention used for VOCs and VPH. Total of 15 surface soil samples.
	ASC01-COMP(0-2)	Naming convention for 3 composite samples.
	ASC01-S1-SS01 (0.5-1) or ASC01-S2-SS01 (0.5-1)	"S1" is for 1st round of step-out samples and "S2" is for 2nd round of step-out samples.

**TABLE 2.1-3. SAMPLE NAMING CONVENTION
 PHASE II REMEDIAL INVESTIGATION REPORT
 FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Task	Naming Convention (Examples)	Comments
<i>Snow Cap - Railroad Loading Racks</i>		
Snow Cap RR Loading Rack	RR-Q01-DP01	Railroad Loading Rack direct push sample.
<i>Railroad Loading/Off-Loading Racks</i>		
Railroad Loading/Off-Loading Racks	RR-A01-DP01	Railroad Loading/Off-Loading Rack direct push sample.
<i>VCP Excavation Verification Sampling</i>		
VCP Verification	VCP06-B03-DP01	Direct push confirmation sampling of VCP excavations, required by MDEQ in October 2010. ID is combination of VCP Excavation number, grid cell number, and borehole number.
<i>Facility Boundary Areas</i>		
Facility East	FE-X04-DP01	Direct push samples in areas not linked to specific refinery features such as; tank berms, VCP excavation areas, etc. Extended the 300 X 300' grid and used same naming convention as the Tank Farm samples. Also, modified when moving north or west since original alpha-numeric grid began at former property line. WAN1 = Grid# for cell west & north of A01. W2A5 = Grid# for cell that is 2 cells west of A05.
Facility North	FN-T02-DP02 or FN-AN2-DP01	
Facility South	FS-P15-DP01	
Facility West	FW-WAN1-DP01	
Facility Step-out	FES1-X04-DP01	
<i>Swanson Property Surface Soil Sampling</i>		
Surface Soil Sampling at Swanson's	DEQ-P10-SS01	Impacts from non-refinery sources; sampling required by MDEQ. Used MDEQ Grid# from 300 X 300' grid, and surface soil sample number.
<i>Tank Berm 34 Downwind</i>		
Wind rose Arc Soil Samples	TB34-DW01	Soil samples collected downwind of Tank Berm 34. Primarily located on an arc equidistant from the center of TB34 and based on a Sunburst wind rose.

**TABLE 2.1-3. SAMPLE NAMING CONVENTION
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Task	Naming Convention (Examples)	Comments
High School Football Field Soil Samples	HSFF-A1	Locations identified by sampling grid created for football field.
Elementary School Playground Soil Samples	ESPG-B1	Locations identified by sampling grid created for playground.
GROUNDWATER INVESTIGATION ACTIVITIES		
<i>MW Installation</i>		
Wells Installed per P2RI	P2RI-22S, P2RI-22D, P2RI-22DF, P2RI-5E, or VCP06-RW	Wells installed used ID or "P2RI", plus an S, D, DF, DFL, DFU, E, or RW designation. S=shallow, D=deep, DF=deep fracture, DFL=deep fracture lower, DFU=deep fracture upper, E=extraction, and RW=recovery well.
Wells Replaced per P2RI	GW-4R	Wells replaced generally retained original ID plus R. R=replacement.
ADDITIONAL MEDIA ACTIIVITIES		
<i>Surface Water & Sediment</i>		
Sediment	SD04-08 or SD01-12	Drainage location and sediment (SD) sample location.
Sediment Step-Out Samples	SD04-13-S1N or SD04-13-S2S	Original sediment sample location, plus 1st (S1) or 2nd (S2) round of step-out sampling, plus sample step-out direction (north, south). Sample naming example: SD04-13-S1N. SD04-13 = original location, S1= 1st round step-out, N = north.
Surface Water (prior to 2012)	DRAINAGE 01	Initial surface water sample sample location/ID, identifying drainage number.
Subsequent Surface Water Samples	SD08-030310SW	IDs were shortened to include "SD" and surface drainage number with the sample date inserted into the "SW" prefix.
Multiple Surface Water Samples	SD01-052110-SW2	Sequential numbering within the "SW" suffix used when multiple samples were collected from a seep or area of surface water.
Surface Sump Samples	SD01-SSUMP-SW or SD01-NSUMP-SW	Included following the installation of sump to assist in collection of surface water from surface drainage SD01.
Drainage Piezometer Locations	SD01-TP-01	Sampling at Temporary Piezometer (TP) at drainage location.

**TABLE 2.1-3. SAMPLE NAMING CONVENTION
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Task	Naming Convention (Examples)	Comments
RESIDENTIAL SUMPS		
<i>Sump Sampling</i>		
Sump Sampling	SI03-SUMP1	Used existing SI naming convention from vapor intrusion work. Note one exception to this: the grid established for the Residential Soil Investigation was used to identify the location (H2P1) of a sump, sampled in March 2011, at the request of the owner.
RESIDENTIAL - TANK BERM SOILS		
<i>Residential Soil Sampling</i>		
Lead Delineation Sampling - original	Reighard-8	New naming convention used both large grid of the town, and smaller grids on individual properties. I1= Block Identifier & P2= Property Identifier from the large Town grid. B03 = Grid number from the 25 X 25' grid established on the property, with sample interval in ().
Excavation Verification Sampling - original	C-M Confirmation_SW#11	
New ID - Lead delineation sampling	I1P2-B03(1-1.5)	
Excavation Verification Sampling - new	I1P2-CF_SW#2	
Residential crawl space samples	I1P2-CF_H1	
QAQC SAMPLES		
<i>Lab Quality Control Samples</i>		
Blind Duplicates	BD01-Date-Media (example: BD01-081610-GW)	Blind duplicate sample collected at a ratio of 1:10 samples.
MS/MSD	Normal ID(MS) and Normal ID(MSD) (example: P2RI-5MS and P2RI-5MSD)	MS/MSD sample collected at a ratio of 1:20 samples.
Equipment/Field Blanks	EB01-Date and FB01-Date (example: EB01-080910)	Equipment Blank collected at a ratio of 1:20 samples.
Trip Blanks	TRIPBLANK01-Date (example: TRIPBLANK01-080910)	Collected as necessary.

Notes:

P2RI - Phase II Remedial Investigation

WP - Work Plan

CEMC - Chevron Environmental Management Company

VCP - Voluntary Cleanup Program

MDEQ - Montana Department of Environmental Quality

**TABLE 3-1. SOIL DELINEATION RATIONALE WITH STEP-OUT SAMPLE AND PARENT SAMPLE IDENTIFICATION FOR LEAD
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Parent Sample Location	Depth (ft-bgs)	Constituents Detected Above Screening Criteria	Step-out Sample ID	NOTES
TB19-G01-SS01	0.17-0.5	Lead (XRF)	TFS1-P11-SS01 and TFS1-P12-SS01	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-P12-SS01(0-0.5).
TF-F04-SS01	0-0.17, 1.5-2	Lead	TFS1-F04-SS01 through TFS1-F04-SS08	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-F04-SS03(0.5-1), TFS1-F04-SS05(0-0.5) and TFS1-F04-SS08(1.5-2).
TF-F07-SS01	0-0.17	Lead, Lead (XRF)	TFS1-F07-SS01 through TFS1-F07-SS09	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-F07-SS01(1.5-2), TFS1-F07-SS05(1-1.5) and TFS1-F07-SS06(0.5-1).
TF-G12-SS01	0-0.17, 0.17-0.5	Lead, Lead (XRF)	TFS1-G12-SS01 through TFS1-G12-SS06, and TFS1-H12-SS01	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-G12-SS03(0-0.5), TFS1-G12-SS05(0.5-1) and TFS1-H12-SS01(1-1.5). Recollected/resubmitted sample from TFS1-G12-SS03(0-0.5) due to container breakage during shipping.
TF-M07-SS01	0-0.17	Lead	TFS1-M07-SS01 through TFS1-M07-SS06	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-M07-SS01(0-0.5), TFS1-M07-SS04(0-0.5), and TFS1-M07-SS06(0.5-1).
TF-M12-SS01	0-0.17, 0.17-0.5	Lead, Lead (XRF)	TFS1-M12-SS01 through TFS1-M12-SS08	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-M12-SS01(1.5-2), TFS1-M12-SS05(1-1.5) and TFS1-M12-SS06(0.5-1).
TF-N12-SS01	0.17-0.5	Lead (XRF)	TFS1-N12-SS01 through TFS1-N12-SS08	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-N12-SS01(0-0.5), TFS1-N12-SS02(1-1.5) and TFS1-N12-SS05(1-1.5).
TF-Q09-SS01	1.5-2	Lead (XRF)	TFS1-Q09-SS01 through TFS1-Q09-SS07	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-Q09-SS01(0-0.5), TFS1-Q09-SS02(0.5-1.0) and TFS1-Q09-SS07(0-0.5).
TF-Q10-SS01	0.5-1, 1-1.5, 1.5-2	Lead	TFS1-Q10-SS01 through TFS1-Q10-SS05	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-Q10-SS01(1-1.5), TFS1-Q10-SS03(1-1.5), TFS1-Q10-SS04(1-1.5), and TFS1-Q10-SS05(1-1.5).
TF-Q11-SS01	0.17-0.5	Lead (XRF)	TFS1-Q11-SS01 through TFS1-Q11-SS05	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-Q11-SS01(0-0.5) and TFS1-Q11-SS05(1.5-2).
TF-Q12-SS01	0.17-0.5	Lead (XRF)	TFS1-Q12-SS01 through TFS1-Q12-SS08	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS1-Q12-SS01(0.5-1), TFS1-Q12-SS03(0-0.5) and TFS1-Q12-SS06(0-0.5).
ASC07-COMP	0-0.5	Lead, Lead (XRF)	ASC07-S1-SS01 through ASC07-S1-SS04	All step-out locations XRF screened at 4 intervals. Samples taken from 0 to 0.5 ft-bgs were submitted for total lead analysis from each location.
ASC08-COMP	0-0.5	Lead (XRF)	ASC07-S1-SS01 through ASC07-S1-SS04	All step-out locations XRF screened at 4 intervals. Samples taken from 0 to 0.5 ft-bgs were submitted for total lead analysis from each location.
ASC11-COMP	0-0.5	Lead, Lead (XRF)	ASC11-S1-SS01 through ASC11-S1-SS05	All step-out locations XRF screened at 4 intervals. Lead samples from locations SS01 through SS04 were taken from 0 to 0.5 ft-bgs. The lead sample from SS05 was taken from 3.5 to 4 ft-bgs.
PC-Q12-DP01	0-4	Lead (XRF)	PCS1-P12-DP01 and PCS1-Q12-DP01	All step-out locations XRF screened at 5 intervals. Samples submitted to lab from PCS1-P12-DP01(1.5-2) and PCS1-Q12-DP01(0-0.5).
SD04-01	0-0.17	Lead	TBD	Sampling will be completed at a later date.
SD04-09	0-0.1 surface	Lead (XRF)	TBD	Sampling will be completed at a later date.
SD04-17	0-0.1 surface	Lead, Lead (XRF)	TBD	Sampling will be completed at a later date.
TFS1-M12-SS08	0-0.5	Lead (XRF)	TFS2-M12-SS01 through TFS2-M12-SS05	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS2-M12-SS02(0.5-1) and TFS2-M12-SS03(0-0.5).
TFS1-Q09-SS02	0-0.5	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample location RR-Q09-DP02.
TFS1-Q09-SS03	0-0.5, 0.5-1	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample locations RR-Q09-DP02 and RR-Q09-DP03.
TFS1-Q09-SS06	0.5-1, 1-1.5, 1.5-2	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample location VCP22-E02-DP01.
TFS1-Q09-SS07	1.5-2	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample locations RR-Q09-DP04 and RR-Q09-DP05.
TFS1-Q10-SS01	0-0.5	Lead	Did not step-out - see "NOTES"	Step-out not needed, bounded on west side by landfill area.
TFS1-Q10-SS02	0.5-1, 1-1.5, 1.5-2	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample location RR-Q10-DP02.
TFS1-Q10-SS05	0.5-1, 1-1.5	Lead, Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample locations VCP14-A01-DP01 and VCP14-A02-DP01.
TFS1-Q11-SS02	0.5-1	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample locations VCP14-A04-DP01, VCP14-A05-DP01, and VCP14-A06-DP01.
TFS1-Q11-SS04	0-0.5	Lead (XRF)	TFS2-Q11-SS06 and TFS2-Q11-SS07	All step-out locations XRF screened at 4 intervals. Samples submitted to lab from TFS2-Q11-SS06(0-0.5) and TFS2-Q11-SS07(1.5-2).
TFS1-Q12-SS02	1-1.5, 1.5-2	Lead (XRF)	Did not step-out - see "NOTES"	Step-out not needed, see nearby sample locations PC-Q12-DP01 and PC-Q12-DP02.
TFS1-Q12-SS05	0.5-1	Lead (XRF)	TFS2-Q12-SS04 through TFS2-Q12-SS06	All step-out locations XRF screened at 4 intervals. Sample submitted to lab from TFS2-Q12-SS05(0.5-1).

Notes:
ft-bgs - feet below ground surface
TB - tank berm
TF - tank farm
DP - deep probe
SS - surface sample
TBD - to be determined
RBSL - risk-based screening level
mg/kg - milligrams per kilogram
ppm - parts per million
Lead - lab sample exceeded the RBSL of 400 mg/kg
Lead (XRF) - XRF screening exceeded the screening criteria of 400 ppm
Lead, Lead (XRF) - both the lab sample and XRF screening exceeded screening criteria (400 mg/kg and 400 ppm, respectively)

**TABLE 3-2. SOIL DELINEATION RATIONALE WITH STEP-OUT SAMPLE AND PARENT SAMPLE IDENTIFICATION FOR ORGANICS
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Parent Sample Location	Parent Sample Depth (ft-bgs)	Constituents Detected Above Screening Criteria	Step-out Sample ID	NOTES
TB02-B05-DP02	4.67-6	VPH	PC-G06-DP01 and TFS1-H07-DP01	PC-G06-DP01: Collected full COI. TFS1-H07-DP01: Collected VOCs, EPH, VPH, and SVOCs.
TB03-F04-DP01	0-0.17	Benzo(a)pyrene	TFS1-E07-SS01	Collected SVOCs and TEL.
TB05-D06-DP01	3-4.33	EPH	TFS1-H08-DP01 and TFS1-I08-DP01	Both: Collected VOCs, EPH, VPH, and SVOCs.
TB07-D06-DP01	0-0.17, 4.67-6	VPH/EPH, Benzo(a)pyrene, Dibenzo(a,h)anthracene, 1,2,4-Trimethylbenzene, 1-Methylnaphthalene, 2-Methylnaphthalene	TFS1-G10-SS01, TFS1-F09-SS01, TFS1-G10-DP01, and TFS1-F09-DP01	TFS1-G10-SS01: Collected SVOCs and EPH. TFS1-F09-SS01: Collected SVOCs and EPH. TFS1-G10-DP01: Collected VOCs, EPH, VPH and SVOCs. TFS1-F09-DP01: Collected VOCs, EPH, VPH and SVOCs.
TB10-C04-DP01	4-8	VPH/EPH, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, 1-Methylnaphthalene	TFS1-F11-DP01	Collected VOCs, EPH, VPH and SVOCs.
TB10-E06-DP01	0-0.17	Pyridine	TFS1-G11-SS01 and TFS1-G11-SS02	TFS1-G11-SS01: Collected VOCs, EPH, VPH, SVOCs and TEL. TFS1-G11-SS02: Collected EPH, SVOCs and TEL.
TB10-F05-SS01	0-0.17	Benzo(a)pyrene	TFS1-G11-SS01	Collected VOCs, EPH, VPH, SVOCs and TEL.
TB11-A05-DP01	0-0.17, 6.67-8	VPH/EPH, Benzo(a)pyrene, 1,2,4-Trimethylbenzene, 1-Methylnaphthalene	TFS1-I11-SS01 and TFS1-I11-DP01	TFS1-I11-SS01: Collected EPH and SVOCs. TFS1-I11-DP01: Collected VOCs, EPH, VPH and SVOCs.
TB11-C06-DP01	8-9.33	1,2,4-Trimethylbenzene, 1-Methylnaphthalene	TFS1-J11-DP01	Collected VOCs, EPH, VPH and SVOCs.
TB12-B02-SS01	0-0.17	Benzo(a)pyrene	TFS1-J10-SS01	Collected EPH, SVOCs and TEL.
TB12-B06-DP01	0-0.17	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, 1-Methylnaphthalene	TFS1-K11-SS01	Collected EPH, SVOCs and TEL.
TB12-B06-SS01	0-0.17	Benzo(a)pyrene, Dibenzo(a,h)anthracene	TFS1-K11-SS01	Collected EPH, SVOCs and TEL.
TB12-E01-SS01	0-0.17	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene	TFS1-K10-SS01	Collected EPH, SVOCs and TEL.
TB12-H03-SS01	0-0.17	Benzo(a)pyrene, Dibenzo(a,h)anthracene	TFS1-L10-SS01	Collected EPH, SVOCs and TEL.
TB12-H08-DP01	0-0.17	Benzo(a)pyrene	TFS1-L11-SS01	Collected EPH, SVOCs and TEL.
TB15-E04-DP01	6.67-8	VPH, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, 1-Methylnaphthalene, 2-Methylnaphthalene	TFS1-G12-DP01	Collected VOCs, EPH, VPH and SVOCs.
TB17-D06-DP01	0-0.17	EPH	TFS1-J13-SS01	Collected EPH.
TB18-D04-SS01	0-0.17	EPH	TFS1-L12-SS01	Collected EPH.
TB18-F02-DP02	2-3.33	VPH, Pyridine, 1,3,5-Trimethylbenzene, 1-Methylnaphthalene	TFS1-M11-DP01	Collected VOCs, EPH, VPH and SVOCs.
TB21-D07-DP01	0-0.17	Benzo(a)anthracene	TFS1-H14-SS01	Collected EPH, SVOCs and TEL.
TB27-D05-DP01	0-0.17, 6.67-8	VPH/EPH, Benzo(a)pyrene, 1-methylnaphthalene, 2-methylnaphthalene	TFS1-N15-DP01	Collected full COI.
TB28-C05-SS01	0-0.17	EPH, Benzo(a)anthracene	TFS1-N14-SS01	Collected SVOCs and EPH.
TB28-D03-DP02	0-0.17	Benzo(a)pyrene	TFS1-O13-SS01	Collected SVOCs and EPH.
TB28-E04-SS01	0-0.17	Benzo(a)pyrene	TFS1-P14-SS01	Collected SVOCs and EPH.
TB30-B03-DP01	0-0.17, 2-3.33	VPH, ethylbenzene, Xylenes, Pyridine, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Cumene, 2,4-Dimethylphenol, 1-Methylnaphthalene, n-Propylbenzene, 2-methylnaphthalene	TFS1-K09-DP01	TFS1-K09-DP01: Collected VOCs, EPH, VPH and SVOCs. TFS1-K09-SS01: Collected SVOCs and EPH.
TB31-D05-DP02	0-0.17, 6.67-8	VPH/EPH, Benzo(a)pyrene, Dibenzo(a,h)anthracene, 1,2,4-Trimethylbenzene, 1-Methylnaphthalene	TFS1-M08-DP01	Collected VOCs, EPH, VPH and SVOCs.
TB31-E04-DP02	0-0.17	EPH	TFS1-M08-SS01	Collected EPH.
TB34-B08-SS01	0-0.17	Benzo(a)pyrene	TFS1-G05-SS01	Collected EPH, SVOCs and TEL.
TB36-B05-DP01	0-0.17	Benzo(a)pyrene	TFS1-A03-SS01	Collected EPH, SVOCs and TEL.
TF-M07-SS01	0-0.17	Benzo(a)pyrene	TFS1-M07-SS01 through TFS1-M07-SS06	Both: Collected VOCs, EPH, VPH, SVOCs, and TEL.
TF-Q10-SS01	1-1.5	Benzo(a)pyrene, 1-Methylnaphthalene	TFS1-Q10-SS01 through TFS1-Q10-SS05	TFS1-Q10-SS01: Collected VOCs, EPH, VPH, SVOCs, and TEL. TFS1-Q10-SS03: Collected VOCs, EPH, VPH, SVOCs, and TEL. TFS1-Q10-SS04: Collected VOCs, EPH, VPH, SVOCs, and TEL.
ASC01-COMP	0-0.5	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, 1-Methylnaphthalene	ASC01-S1-SS01 through ASC01-S1-SS04	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC02-COMP	0-0.5	EPH, Benzo(a)pyrene, Dibenzo(a,h)anthracene	ASC02-S1-SS01 through ASC02-S1-SS07	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC03-COMP	0-0.5	EPH	ASC03-S1-SS01 through ASC03-S1-SS04	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC04-COMP	0-0.5	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Indeno(1,2,3-cd)pyrene	ASC04-S1-SS01 through ASC04-S1-SS05	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC05-COMP	0-0.5	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene, 1-Methylnaphthalene	ASC05-S1-SS01 through ASC05-S1-SS05	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC07-COMP	0-0.5	EPH, Benzo(a)pyrene, Indeno(1,2,3-cd)pyrene	ASC07-S1-SS01 through ASC07-S1-SS04	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC08-COMP	0-0.5	EPH, Benzo(a)pyrene, Dibenzo(a,h)anthracene, Indeno(1,2,3-cd)pyrene	ASC08-S1-SS01 through ASC08-S1-SS04	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC09-COMP	0-0.5	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b)fluoranthene, Indeno(1,2,3-cd)pyrene	ASC09-S1-SS01 through ASC09-S1-SS06	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
ASC10-COMP	0-0.5	EPH, Benzo(a)anthracene, Benzo(a)pyrene, Dibenzo(a,h)anthracene	ASC10-S1-SS01 through ASC10-S1-SS11	All locations: Collected EPH, SVOCs, TEL, Metals, Arsenic, Mercury, and Cyanide from 0-0.5 ft-bgs; collected VOCs and VPH from 1.5-2 ft-bgs.
PC-G06-DP01	10	VPH, EPH, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Benzene, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Parent location and proposed step-out locations are near the P2RI-45 monitoring well cluster (an area that has documented impacts). Parent sample collection depths are also within the smear zone.
PC-G06-DP02	10	1,2,4-Trimethylbenzene, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Parent location and proposed step-out locations are near the P2RI-45 monitoring well cluster (an area that has documented impacts). Parent sample collection depths are also within the smear zone.
PC-G07-DP01	10	VPH, EPH, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Parent location and proposed step-out locations are near the P2RI-45 monitoring well cluster (an area that has documented impacts). Parent sample collection depths are also within the smear zone.
PC-P14-DP01	9-11	VPH, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Parent sample collected below the water table, within the smear zone. The borehole log indicates moist to wet at 8 ft-bgs with hydrocarbon impacts starting at 7.5 ft-bgs. Depth the groundwater is confirmed by nearby recovery well VCP06-RW.
PC-Q13-DP01	6-8	VPH, EPH, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Based on documentation associated with the nearby recovery well VCP06-RW and soil boring PC-P14-DP01, this parent sample was likely taken from the smear zone.
PC-I08-DP01	10	VPH, EPH, 1,2,4-Trimethylbenzene, 1,3,5-Trimethylbenzene, Benzene, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Step-out samples are not needed due to the bounding proximity of Tank Berm 5 (and associated borings), as well as a previously addressed historic pipeline run.
PC-N08-DP02	12	Benzene, 1-Methylnaphthalene, 2-Methylnaphthalene	Did not step-out - see "NOTES"	Parent sample was taken from a depth inconsistent with the sample procedures (based on visual impacts). Photos from the early 2000s show excavation work in this area. Based on the borehole logs (PID/FID readings and visual soil analysis), the top 10 ft of soil appear clean.
TF-L14-SS01	0-0.17	Pyridine	TFS1-L14-01 through TFS1-L14-04	All locations: Collected SVOCs and EPH.
TF-P14-SS01	0-0.17	Benzo(a)pyrene, Dibenzo(a,h)anthracene	TFS1-P14-SS01	Collected SVOCs and EPH.
TFS1-Q10-SS01	1-1.5	Benzo(a)pyrene, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Step-out not needed. Parent sample bounded on west side by existing landfill area and east side by county road.
TFS1-Q10-SS03	1-1.5	Benzo(a)pyrene	Did not step-out - see "NOTES"	Step-out not needed. Parent sample bounded on east side by VCP14-A01-DP01.
TFS1-L10-SS01	0-0.5	Benzo(a)pyrene	TFS2-L10-01	Collected SVOCs and EPH.
TFS1-A03-SS01	0-0.5	Benzo(a)pyrene	TFS2-A03-01	Collected SVOCs and EPH.
TFS1-J10-SS01	0-0.5	Benzo(a)pyrene	TFS2-J10-01	Collected SVOCs and EPH.
TFS1-G11-SS01	0-0.5	Benzo(a)pyrene	TFS2-G11-01	Collected SVOCs and EPH.
TFS1-H07-DP01	15-16	1,2,4-Trimethylbenzene, Benzene, 1-Methylnaphthalene	Did not step-out - see "NOTES"	Parent sample field form indicates that sample was likely taken from the groundwater smear zone.
TFS1-K10-SS01	0-0.5	EPH	TFS2-K10-01 and TFS2-K10-02	Collected SVOCs and EPH.

Notes:
ft-bgs - feet below ground surface
TB - tank berm
TF - tank farm
DP - deep probe
SS - surface sample
VOCs - volatile organic compounds
SVOCs - semi-volatile organic compounds
TEL - tetraethyl lead
EPH - extractable petroleum hydrocarbons
VPH - volatile petroleum hydrocarbons
COI - constituents of interest
Full COI - VOCs, SVOCs, TEL, Metals, Arsenic, Mercury, Cyanide, MT EPH, and MT VPH.

**TABLE 3.1-1. TANK BERM SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	678	133	19.62%	3.32	TB27-D02-SS01 (0-0.17 ft)	2	2	678	3.1	2.7	0.368
Arsenic, Total	c	671	671	100.00%	39.8	TB03-E04-DP01 (0-0.17 ft)	671	671	4	0.61	2.9	25.1
Barium, Total	n	678	678	100.00%	1100 J	TB34-B08-SS01 (1.5-2 ft)	0	26	39	1,500	414	392
Beryllium, Total	n	678	678	100.00%	1.45	TB21-D05-DP01 (0-0.17 ft)	0	0	232	16	32	0.817
Cadmium, Total	n	678	626	92.33%	2.61 J	TB18-D02-DP01 (0-0.17 ft)	0	0	113	7	3.8	1.17
Chromium, Total	n	678	678	100.00%	42.6 J	TB08-D03-DP01 (0-0.17 ft)	0	0	42	12,000	1,800,000	30.8
Cobalt, Total	n	678	678	100.00%	11.3	TB27-C03-SS01 (0.5-1 ft)	678	678	25	2.3	2.1	9.13
Copper, Total	n	678	678	100.00%	322	TB26-F05-DP02 (0-0.17 ft)	1	0	16	310	460	26.6
Cyanide, Total	n	396	43	10.86%	3.92 J	TB27-D05-SS01 (0-0.17 ft)	0	0	0	4.7	20	NA
Lead, Total	L*	678	678	100.00%	61700	TB03-E04-DP01 (0-0.17 ft)	31	60	194	400	140	30.2
Mercury, Total	n	671	647	96.42%	2.69 JB	TB08-D04-DP01 (0-0.17 ft)	1	0	25	2.3	NA	0.0837
Nickel, Total	n	678	678	100.00%	60.7	TB10-D02-DP01 (0-0.17 ft)	0	0	7	150	147	32.6
Selenium, Total	n	678	209	30.83%	3.05	TB22-C02-SS01 (0-0.17 ft)	0	11	32	39	2.6	2.09
Silver, Total	n	678	103	15.19%	0.799	TB18-D02-DP01 (0-0.17 ft)	0	0	678	39	6	0.168
Vanadium, Total	n	678	678	100.00%	106 J	TB37-F05-SS01 (1-1.5 ft)	588	0	123	39	700	63.9
Zinc, Total	n	678	678	100.00%	254	TB22-B06-SS01 (0-0.17 ft)	0	0	12	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Benzene	c	392	22	5.61%	0.112 J	TB25-D03-DP01 (1.5-2 ft)	0	1	1	0.04
2-Butanone	n	392	2	0.51%	0.566 J	TB25-D03-DP01 (1.5-2 ft)	0	0	2,800	10
n-Butylbenzene	n	392	5	1.28%	16.5	TB25-D03-DP01 (1.5-2 ft)	0	2	390	2.5
sec-Butylbenzene	n	392	3	0.77%	11.4	TB25-D03-DP01 (1.5-2 ft)	0	2	780	4.6
tert-Butylbenzene	n	392	1	0.26%	0.425	TB25-D03-DP01 (1.5-2 ft)	0	0	780	1.1
Carbon Disulfide	n	392	1	0.26%	0.00537	TB28-C05-SS01 (1.5-2 ft)	0	0	82	2.1
Chlorobenzene	n	392	0	0.00%	--		0	0	29	0.68
Chloroform	c	392	1	0.26%	0.00111 JB	TB05-B04-DP01 (1.5-2 ft)	0	0	0.29	0.2
Cyclohexane	n	392	10	2.55%	14.2	TB25-D03-DP01 (1.5-2 ft)	0	0	700	130
1,2-Dibromoethane	c	392	0	0.00%	--		0	0	0.04	0.00002
1,1-Dichloroethane	c	392	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	392	1	0.26%	0.00109 J	TB30-B01-DP01 (1.5-2 ft)	0	0	0.5	0.01
Ethylbenzene	c	392	10	2.55%	20	TB25-D03-DP01 (1.5-2 ft)	2	1	6	10
Hexane	n	392	9	2.30%	3.42	TB25-D03-DP01 (1.5-2 ft)	0	0	57	18
Isopropylbenzene	n	392	6	1.53%	9.67	TB25-D03-DP01 (1.5-2 ft)	0	1	210	6.4
MTBE	c	392	0	0.00%	--		0	0	40	0.08
n-Propylbenzene	n	392	4	1.02%	16.5	TB25-D03-DP01 (1.5-2 ft)	0	1	340	9.9
Styrene	n	392	0	0.00%	--		0	0	630	1.1
Tetrachloroethene	c	392	0	0.00%	--		0	0	8.6	0.023
Toluene	n	392	33	8.42%	12.6	TB30-B03-DP01 (1.5-2 ft)	0	1	600	10
1,1,1-Trichloroethane	n	392	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	392	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	392	10	2.55%	192	TB30-B03-DP01 (1.5-2 ft)	3	3	6.2	0.24
1,3,5-Trimethylbenzene	n	392	14	3.57%	130 J	TB30-B03-DP01 (1.5-2 ft)	1	3	78	1.2
m,p-Xylene	n	392	25	6.38%	192 J	TB30-B03-DP01 (1.5-2 ft)	1	1	59	94.74
o-Xylene	n	392	11	2.81%	137 J	TB30-B03-DP01 (1.5-2 ft)	1	1	69	100
Xylenes, Total	n	392	25	6.38%	330 J	TB30-B03-DP01 (1.5-2 ft)	1	1	70	200

**TABLE 3.1-1. TANK BERM SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Acenaphthene	n	394	0	0.00%	--		0	0	400	200
Anthracene	n	394	3	0.76%	0.289 J	TB12-B06-DP01 (0-0.17 ft)	0	0	2,000	4,000
Benzo(a)anthracene	c	394	10	2.54%	5.82 J	TB12-E01-SS01 (0-0.17 ft)	4	0	0.2	10
Benzo(a)pyrene	c	394	56	14.21%	5.45 J	TB12-E01-SS01 (0-0.17 ft)	24	1	0.02	4
Benzo(b)fluoranthene	c	394	12	3.05%	3.22 J	TB12-E01-SS01 (0-0.17 ft)	4	0	0.2	50
Benzo(k)fluoranthene	c	394	2	0.51%	0.0538 J	TB36-B05-DP01 (0-0.17 ft)	0	0	2	500
Bis(2-ethylhexyl)phthalate	c	394	18	4.57%	0.626	TB03-E02-SS01 (1.5-2 ft)	0	0	35	14
Chrysene	c	394	27	6.85%	12.4	TB12-E01-SS01 (0-0.17 ft)	0	0	20	2,000
Dibenz(a,h)acridine	--	394	1	0.25%	0.0728 J	TB25-E04-DP02 (0-0.17 ft)	0	0	NA	NA
Dibenzo(a,h)anthracene	c	394	30	7.61%	1.07 J	TB12-E01-SS01 (0-0.17 ft)	9	0	0.02	7
1,2-Dichlorobenzene	n	394	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	394	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	394	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	394	1	0.25%	0.11 J	TB10-E06-DP01 (0-0.17 ft)	0	0	4,900	72.64
2,4-Dimethylphenol	n	394	3	0.76%	0.475	TB03-E04-DP01 (0-0.17 ft)	0	0	120	4.5
Dimethylphthalate	--	394	1	0.25%	1.55	TB20-E07-SS01 (0-0.17 ft)	0	0	NA	NA
Di-n-butylphthalate	n	394	0	0.00%	--		0	0	610	50.75
2,4-Dinitrophenol	n	394	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	394	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	394	6	1.52%	3.72 J	TB12-E01-SS01 (0-0.17 ft)	0	0	300	600
Fluorene	n	394	0	0.00%	--		0	0	300	600
Indene	--	394	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	394	8	2.03%	0.37 J	TB12-B06-DP01 (0-0.17 ft)	1	0	0.2	100
Tetraethyl Lead	n	405	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	394	10	2.54%	0.451 J	TB12-B06-DP01 (0-0.17 ft)	0	8	16	0.051
2-Methylnaphthalene	n	394	11	2.79%	0.509 J	TB12-B06-DP01 (0-0.17 ft)	0	0	23	4.4
2-Methylphenol	n	394	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	394	1	0.25%	0.103 J	TB20-G03-SS01 (0-0.17 ft)	0	0	610	44
Naphthalene	n	394	2	0.51%	0.138 J	TB30-B03-DP01 (0-0.17 ft)	0	0	4	0
4-Nitrophenol	--	394	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	394	16	4.06%	4.46 J	TB12-E01-SS01 (0-0.17 ft)	0	0	NA	NA
Phenol	n	394	6	1.52%	0.33	TB15-C02-SS01 (0-0.17 ft)	0	0	1,800	4.73
Pyrene	c	394	25	6.35%	48.3	TB12-E01-SS01 (0-0.17 ft)	0	0	200	4,000
Pyridine	n	394	3	0.76%	1.94	TB03-E04-DP01 (0-0.17 ft)	0	3	7.8	0.053
Quinoline	c	394	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	394	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.1-1. TANK BERM SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	391	5	1.28%	6170	TB30-B03-DP01 (1.5-2 ft)	3	2	60	200
C9-C10, Aromatic, Adjusted	n	391	10	2.56%	13300 J	TB30-B03-DP01 (1.5-2 ft)	3	3	100	400
C9-C12, Aliphatic, Adjusted	n	391	9	2.30%	16800 J	TB30-B03-DP01 (1.5-2 ft)	3	4	100	40,000
C9-C18, Aliphatic, Adjusted	n	87	23	5.84%	124 J	TB12-E01-SS01 (0-0.17 ft)	0	0	200	50,000
C11-C22, Aromatic, Adjusted	n	87	76	19.29%	2480	TB12-E01-SS01 (0-0.17 ft)	6	6	500	400
C19-C36, Aliphatic, Adjusted	n	87	84	21.32%	1730 J	TB12-E01-SS01 (0-0.17 ft)	0	0	20,000	NA
Total Extractable Hydrocarbons	n	394	87	22.08%	7770	TB11-A05-DP01 (0-0.17 ft)	0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

JB - estimated concentration due to blank contamination

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.1-2. TANK BERM SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	214	34	15.89%	18.2 J	TB05-D06-DP01 (3-4.33 ft)	5	5	214	3.1	2.7	0.368
Arsenic, Total	c	214	214	100.00%	72.9	TB18-F02-DP02 (2-3.33 ft)	214	214	4	0.61	2.9	25.1
Barium, Total	n	214	214	100.00%	435 J	TB11-D04-DP01 (2-3.33 ft)	0	2	6	1,500	444	392
Beryllium, Total	n	214	214	100.00%	1.33	TB21-F02-DP01 (2-3.33 ft)	0	0	59	16	32	0.817
Cadmium, Total	n	214	188	87.85%	5.01	TB27-D05-DP01 (6.67-8 ft)	0	4	9	7	3.8	1.17
Chromium, Total	n	214	214	100.00%	66.5	TB05-D06-DP01 (3-4.33 ft)	0	0	14	12,000	1,800,000	30.8
Cobalt, Total	n	214	214	100.00%	20.9	TB05-D06-DP01 (3-4.33 ft)	214	214	27	2.3	2.4	9.13
Copper, Total	n	214	214	100.00%	193	TB05-D06-DP01 (3-4.33 ft)	0	0	7	310	460	26.6
Cyanide, Total	n	214	1	0.47%	0.362 J	TB01-D04-DP01 (4.67-6 ft)	0	0	0	4.7	20	NA
Lead, Total	L*	214	214	100.00%	106000 J	TB30-B03-DP01 (2-3.33 ft)	6	9	14	400	440	30.2
Mercury, Total	n	214	208	97.20%	0.829	TB30-B03-DP01 (2-3.33 ft)	0	0	8	2.3	NA	0.0837
Nickel, Total	n	214	214	100.00%	92.6	TB05-D06-DP01 (3-4.33 ft)	0	0	9	150	447	32.6
Selenium, Total	n	214	21	9.81%	2.41	TB23-B07-DP01 (4.67-6 ft)	0	2	3	39	2.6	2.09
Silver, Total	n	214	7	3.27%	0.313 J	TB38-F02-DP01 (2-3.33 ft)	0	0	214	39	6	0.168
Vanadium, Total	n	214	214	100.00%	99.2 J	TB18-D02-DP01 (4.67-6 ft)	161	0	26	39	700	63.9
Zinc, Total	n	214	214	100.00%	304 J	TB31-B03-DP01 (4.67-6 ft)	0	0	4	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Benzene	c	214	12	5.61%	2.16	TB30-B03-DP01 (2-3.33 ft)	0	7	200	0.04
2-Butanone	n	214	3	1.40%	1.52	TB30-B03-DP01 (2-3.33 ft)	0	0	2,800	40
n-Butylbenzene	n	214	14	6.54%	33 J	TB30-B03-DP01 (2-3.33 ft)	0	5	390	2.5
sec-Butylbenzene	n	214	21	9.81%	14 J	TB30-B03-DP01 (2-3.33 ft)	0	4	780	4.6
tert-Butylbenzene	n	214	7	3.27%	0.372	TB25-D03-DP01 (2.67-4 ft)	0	0	780	1.1
Carbon Disulfide	n	214	1	0.47%	0.0591 J	TB15-E04-DP01 (6.67-8 ft)	0	0	82	2.4
Chlorobenzene	n	214	0	0.00%	--		0	0	29	0.68
Chloroform	c	214	0	0.00%	--		0	0	0.29	0.2
Cyclohexane	n	214	15	7.01%	19	TB30-B03-DP01 (2-3.33 ft)	0	0	700	430
1,2-Dibromoethane	c	214	0	0.00%	--		0	0	7	0.00002
1,1-Dichloroethane	c	214	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	214	1	0.47%	0.0011 J	TB30-E03-DP01 (2-3.33 ft)	0	0	104	0.01
Ethylbenzene	c	214	16	7.48%	127 J	TB30-B03-DP01 (2-3.33 ft)	0	2	1,000	10
Hexane	n	214	13	6.07%	25.9	TB05-C04-DP02 (12.67-14 ft)	0	4	57	48
Isopropylbenzene	n	214	14	6.54%	29.2 J	TB30-B03-DP01 (2-3.33 ft)	0	2	210	6.4
MTBE	c	214	0	0.00%	--		0	0	8,000	0.08
n-Propylbenzene	n	214	15	7.01%	60.9 J	TB30-B03-DP01 (2-3.33 ft)	0	2	340	9.9
Styrene	n	214	0	0.00%	--		0	0	630	4.4
Tetrachloroethene	c	214	0	0.00%	--		0	0	8.6	0.023
Toluene	n	214	21	9.81%	203	TB30-B03-DP01 (2-3.33 ft)	0	4	5,000	40
1,1,1-Trichloroethane	n	214	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	214	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	214	25	11.68%	520	TB30-B03-DP01 (2-3.33 ft)	8	44	6.2	0.24
1,3,5-Trimethylbenzene	n	214	22	10.28%	165 J	TB30-B03-DP01 (2-3.33 ft)	1	44	78	4.2
m,p-Xylene	n	214	26	12.15%	914 J	TB30-B03-DP01 (2-3.33 ft)	2	2	59	94.74
o-Xylene	n	214	16	7.48%	444 J	TB30-B03-DP01 (2-3.33 ft)	1	4	69	400
Xylenes, Total	n	214	27	12.62%	1400 J	TB30-B03-DP01 (2-3.33 ft)	1	4	600	200

**TABLE 3.1-2. TANK BERM SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Acenaphthene	n	214	4	1.87%	4.69 J	TB07-D06-DP01 (4.67-6 ft)	0	0	4,000	200
Anthracene	n	214	7	3.27%	19.2	TB07-D06-DP01 (4.67-6 ft)	0	0	20,000	4,000
Benzo(a)anthracene	c	214	6	2.80%	11.9	TB07-D06-DP01 (4.67-6 ft)	0	1	50	10
Benzo(a)pyrene	c	214	20	9.35%	7.09 J	TB07-D06-DP01 (4.67-6 ft)	1	1	5	4
Benzo(b)fluoranthene	c	214	5	2.34%	2.76 J	TB07-D06-DP01 (4.67-6 ft)	0	0	50	50
Benzo(k)fluoranthene	c	214	1	0.47%	0.176 J	TB21-F02-DP01 (2-3.33 ft)	0	0	500	500
Bis(2-ethylhexyl)phthalate	c	214	3	1.40%	0.288 J	TB27-D05-DP01 (6.67-8 ft)	0	0	35	14
Chrysene	c	214	16	7.48%	18	TB07-D06-DP01 (4.67-6 ft)	0	0	5,000	2,000
Dibenz(a,h)acridine	--	214	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	214	14	6.54%	1.56 J	TB07-D06-DP01 (4.67-6 ft)	0	0	5	7
1,2-Dichlorobenzene	n	214	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	214	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	214	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	214	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	214	4	1.87%	19 J	TB30-B03-DP01 (2-3.33 ft)	0	4	120	4.5
Dimethylphthalate	--	214	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	214	0	0.00%	--		0	0	610	50.75
2,4-Dinitrophenol	n	214	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	214	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	214	4	1.87%	4.45 J	TB07-D06-DP01 (4.67-6 ft)	0	0	2,000	500
Fluorene	n	214	18	8.41%	15.6	TB07-D06-DP01 (4.67-6 ft)	0	0	2,000	600
Indene	--	214	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	214	4	1.87%	0.221 J	TB21-F02-DP01 (2-3.33 ft)	0	0	50	100
Tetraethyl Lead	n	214	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	214	19	8.88%	45.7	TB30-B03-DP01 (2-3.33 ft)	3	19	16	0.051
2-Methylnaphthalene	n	214	20	9.35%	92.6	TB30-B03-DP01 (2-3.33 ft)	4	40	23	4.4
2-Methylphenol	n	214	1	0.47%	9.01 J	TB30-B03-DP01 (2-3.33 ft)	0	4	310	5.8
4-Methylphenol	n	214	0	0.00%	--		0	0	610	44
Naphthalene	n	214	15	7.01%	152 J	TB30-B03-DP01 (2-3.33 ft)	0	2	200	9
4-Nitrophenol	--	214	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	214	21	9.81%	74.5	TB07-D06-DP01 (4.67-6 ft)	0	0	NA	NA
Phenol	n	214	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	214	15	7.01%	39.7	TB07-D06-DP01 (4.67-6 ft)	0	0	2,000	4,000
Pyridine	n	214	1	0.47%	2.25 J	TB18-F02-DP02 (2-3.33 ft)	0	4	7.8	0.053
Quinoline	c	214	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	214	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.1-2. TANK BERM SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	214	21	9.81%	7940	TB30-B03-DP01 (2-3.33 ft)	3	5	500	200
C9-C10, Aromatic, Adjusted	n	214	25	11.68%	11900 J	TB30-B03-DP01 (2-3.33 ft)	3	46	1,000	400
C9-C12, Aliphatic, Adjusted	n	214	26	12.15%	14700 J	TB30-B03-DP01 (2-3.33 ft)	3	4	1,000	40,000
C9-C18, Aliphatic, Adjusted	n	43	31	14.49%	15800 J	TB25-D03-DP01 (2.67-4 ft)	6	0	2,000	50,000
C11-C22, Aromatic, Adjusted	n	43	31	14.49%	13200	TB07-D06-DP01 (4.67-6 ft)	3	44	4,000	400
C19-C36, Aliphatic, Adjusted	n	43	32	14.95%	16900	TB25-D03-DP01 (2.67-4 ft)	0	0	100,000	NA
Total Extractable Hydrocarbons	n	214	34	15.89%	28000	TB10-C04-DP01 (4-8 ft)	0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.2-1. TANK FARM SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	50	11	22.00%	2.32	TF-Q10-SS01 (0.5-1 ft)	0	0	50	3.1	2.7	0.368
Arsenic, Total	c	50	50	100.00%	23.1	TF-C13-SS01 (0.5-1 ft)	50	50	0	0.61	2.9	25.1
Barium, Total	n	50	50	100.00%	853 J	TF-L14-SS01 (0.5-1 ft)	0	6	6	1,500	444	392
Beryllium, Total	n	50	50	100.00%	1.25	TF-G12-SS01 (0.17-0.5 ft)	0	0	28	16	32	0.817
Cadmium, Total	n	50	47	94.00%	2.72	TF-M07-SS01 (0-0.17 ft)	0	0	18	7	3.8	1.17
Chromium, Total	n	50	50	100.00%	45.9 J	TF-M07-SS01 (0-0.17 ft)	0	0	3	12,000	1,800,000	30.8
Cobalt, Total	n	50	50	100.00%	9.79	TF-G12-SS01 (0.17-0.5 ft), TF-I10-SS01 (0.17-0.5 ft)	50	50	4	2.3	2.4	9.13
Copper, Total	n	50	50	100.00%	107	TF-M07-SS01 (0-0.17 ft)	0	0	5	310	460	26.6
Cyanide, Total	n	19	3	15.79%	0.819 J	TF-G12-SS01 (0-0.17 ft)	0	0	0	4.7	20	NA
Lead, Total	L*	84	84	100.00%	2000	TF-M07-SS01 (0-0.17 ft)	10	26	44	400	140	30.2
Mercury, Total	n	50	49	98.00%	3.4	TF-M07-SS01 (0-0.17 ft)	1	0	9	2.3	NA	0.0837
Nickel, Total	n	50	50	100.00%	37.7	TF-M07-SS01 (0-0.17 ft)	0	0	2	150	147	32.6
Selenium, Total	n	50	43	86.00%	2.76	TF-Q10-SS01 (0.5-1 ft)	0	3	15	39	2.6	2.09
Silver, Total	n	50	26	52.00%	0.805	TF-G12-SS01 (0.17-0.5 ft)	0	0	50	39	6	0.168
Vanadium, Total	n	50	50	100.00%	90.2 J	TF-G12-SS01 (0.17-0.5 ft)	47	0	17	39	780	63.9
Zinc, Total	n	50	50	100.00%	181	TF-M07-SS01 (0-0.17 ft)	0	0	1	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Benzene	c	25	4	16.00%	0.00105 J	TF-F04-SS01 (1.5-2 ft)	0	0	1	0.04
2-Butanone	n	25	0	0.00%	--		0	0	2,800	40
n-Butylbenzene	n	25	0	0.00%	--		0	0	390	2.5
sec-Butylbenzene	n	25	0	0.00%	--		0	0	780	4.6
tert-Butylbenzene	n	25	0	0.00%	--		0	0	780	4.4
Carbon Disulfide	n	25	0	0.00%	--		0	0	82	2.1
Chlorobenzene	n	25	0	0.00%	--		0	0	29	0.68
Chloroform	c	25	0	0.00%	--		0	0	0.29	0.2
Cyclohexane	n	25	0	0.00%	--		0	0	700	430
1,2-Dibromoethane	c	25	0	0.00%	--		0	0	0.04	0.00002
1,1-Dichloroethane	c	25	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	25	0	0.00%	--		0	0	0.5	0.01
Ethylbenzene	c	25	0	0.00%	--		0	0	6	10
Hexane	n	25	3	12.00%	0.00238 J	TFS1-Q10-SS01 (1-1.5 ft)	0	0	57	48
Isopropylbenzene	n	25	0	0.00%	--		0	0	210	6.4
MTBE	c	25	0	0.00%	--		0	0	40	0.08
n-Propylbenzene	n	25	0	0.00%	--		0	0	340	9.9
Styrene	n	25	0	0.00%	--		0	0	630	4.4
Tetrachloroethene	c	25	1	4.00%	0.00113 J	TF-Q10-SS01 (1-1.5 ft)	0	0	8.6	0.023
Toluene	n	25	1	4.00%	0.00108 J	TF-N10-SS01 (1.5-2 ft)	0	0	600	40
1,1,1-Trichloroethane	n	25	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	25	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	25	0	0.00%	--		0	0	6.2	0.24
1,3,5-Trimethylbenzene	n	25	0	0.00%	--		0	0	78	4.2
m,p-Xylene	n	25	0	0.00%	--		0	0	59	94.74
o-Xylene	n	25	0	0.00%	--		0	0	69	400
Xylenes, Total	n	25	0	0.00%	--		0	0	70	200

**TABLE 3.2-1. TANK FARM SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Acenaphthene	n	51	0	0.00%	--		0	0	400	200
Anthracene	n	51	2	3.92%	0.011 J	TFS2-L10-01 (0-0.5 ft)	0	0	2,000	4,000
Benzo(a)anthracene	c	51	7	13.73%	0.0806 J	TFS1-L11-SS01 (0-0.5 ft)	0	0	0.2	10
Benzo(a)pyrene	c	51	21	41.18%	0.17 J	TFS1-Q10-SS03 (1-1.5 ft)	8	0	0.02	4
Benzo(b)fluoranthene	c	51	16	31.37%	0.335	TF-G12-SS01 (0-0.17 ft)	3	0	0.2	50
Benzo(k)fluoranthene	c	51	2	3.92%	0.0066 J	TFS2-A03-01 (0-0.5 ft)	0	0	2	500
Bis(2-ethylhexyl)phthalate	c	51	3	5.88%	0.186 J	TF-P14-SS01 (0-0.17 ft)	0	0	35	14
Chrysene	c	51	16	31.37%	0.1 J	TFS2-G11-01 (0-0.5 ft)	0	0	20	2,000
Dibenz(a,h)acridine	--	51	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	51	8	15.69%	0.0159 J	TF-Q10-SS01 (1-1.5 ft)	0	0	0.02	7
1,2-Dichlorobenzene	n	51	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	51	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	51	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	51	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	51	0	0.00%	--		0	0	120	4.5
Dimethylphthalate	--	51	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	51	5	9.80%	0.191 J	TF-Q10-SS01 (0-0.17 ft)	0	0	610	50.75
2,4-Dinitrophenol	n	51	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	51	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	51	8	15.69%	0.0573 J	TF-M07-SS01 (0-0.17 ft)	0	0	300	600
Fluorene	n	51	0	0.00%	--		0	0	300	600
Indene	--	51	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	51	6	11.76%	0.074 J	TFS2-G11-01 (0-0.5 ft)	0	0	0.2	100
Tetraethyl Lead	n	38	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	51	3	5.88%	0.464	TFS1-Q10-SS01 (1-1.5 ft)	0	2	16	0.051
2-Methylnaphthalene	n	51	2	3.92%	0.749	TFS1-Q10-SS01 (1-1.5 ft)	0	0	23	4.4
2-Methylphenol	n	51	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	51	0	0.00%	--		0	0	610	44
Naphthalene	n	51	3	5.88%	0.428	TFS1-Q10-SS01 (1-1.5 ft)	0	0	4	0
4-Nitrophenol	--	51	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	51	11	21.57%	0.119 J	TFS1-Q10-SS01 (1-1.5 ft)	0	0	NA	NA
Phenol	n	51	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	51	16	31.37%	0.0853 J	TF-M07-SS01 (0-0.17 ft)	0	0	200	4,000
Pyridine	n	51	1	1.96%	0.136 J	TF-L14-SS01 (0-0.17 ft)	0	4	7.8	0.053
Quinoline	c	51	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	51	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.2-1. TANK FARM SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	25	0	0.00%	--		0	0	60	200
C9-C10, Aromatic, Adjusted	n	25	0	0.00%	--		0	0	100	400
C9-C12, Aliphatic, Adjusted	n	25	1	4.00%	5.39 J	TFS1-Q10-SS01 (1-1.5 ft)	0	0	100	40,000
C9-C18, Aliphatic, Adjusted	n	15	3	5.56%	32.9	TF-Q10-SS01 (1-1.5 ft)	0	0	200	50,000
C11-C22, Aromatic, Adjusted	n	15	14	25.93%	603	TFS1-K10-SS01 (0-0.5 ft)	1	1	500	400
C19-C36, Aliphatic, Adjusted	n	15	14	25.93%	308	TFS1-K10-SS01 (0-0.5 ft)	0	0	20,000	NA
Total Extractable Hydrocarbons	n	54	16	29.63%	1970 J	TFS1-K10-SS01 (0-0.5 ft)	0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.2-2. TANK FARM SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	1	0	0.00%	--		0	0	1	3.1	2.7	0.368
Arsenic, Total	c	1	1	100.00%	10.8	TFS1-N15-DP01 (4-6 ft)	1	1	0	0.61	2.9	25.1
Barium, Total	n	1	1	100.00%	253 J	TFS1-N15-DP01 (4-6 ft)	0	0	0	1,500	444	392
Beryllium, Total	n	1	1	100.00%	0.641	TFS1-N15-DP01 (4-6 ft)	0	0	0	16	32	0.817
Cadmium, Total	n	1	1	100.00%	0.457 J	TFS1-N15-DP01 (4-6 ft)	0	0	0	7	3.8	1.17
Chromium, Total	n	1	1	100.00%	17.5 J	TFS1-N15-DP01 (4-6 ft)	0	0	0	12,000	1,800,000	30.8
Cobalt, Total	n	1	1	100.00%	6.51	TFS1-N15-DP01 (4-6 ft)	1	1	0	2.3	2.1	9.13
Copper, Total	n	1	1	100.00%	16.3	TFS1-N15-DP01 (4-6 ft)	0	0	0	310	460	26.6
Cyanide, Total	n	1	0	0.00%	--		0	0	0	4.7	20	NA
Lead, Total	L*	1	1	100.00%	9.79 J	TFS1-N15-DP01 (4-6 ft)	0	0	0	400	140	30.2
Mercury, Total	n	1	1	100.00%	0.0352 J	TFS1-N15-DP01 (4-6 ft)	0	0	0	2.3	NA	0.0837
Nickel, Total	n	1	1	100.00%	18.9	TFS1-N15-DP01 (4-6 ft)	0	0	0	150	147	32.6
Selenium, Total	n	1	0	0.00%	--		0	0	0	39	2.6	2.09
Silver, Total	n	1	0	0.00%	--		0	0	1	39	6	0.168
Vanadium, Total	n	1	1	100.00%	35.6 J	TFS1-N15-DP01 (4-6 ft)	0	0	0	39	700	63.9
Zinc, Total	n	1	1	100.00%	62.8	TFS1-N15-DP01 (4-6 ft)	0	0	0	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Benzene	c	12	1	8.33%	0.267 J	TFS1-H07-DP01 (15-16 ft)	0	1	200	0.04
2-Butanone	n	12	0	0.00%	--		0	0	2,800	40
n-Butylbenzene	n	12	2	16.67%	0.311	TFS1-H07-DP01 (15-16 ft)	0	0	390	2.5
sec-Butylbenzene	n	12	1	8.33%	0.178 J	TFS1-H07-DP01 (15-16 ft)	0	0	780	4.6
tert-Butylbenzene	n	12	0	0.00%	--		0	0	780	1.1
Carbon Disulfide	n	12	0	0.00%	--		0	0	82	2.1
Chlorobenzene	n	12	0	0.00%	--		0	0	29	0.68
Chloroform	c	12	0	0.00%	--		0	0	0.29	0.2
Cyclohexane	n	12	1	8.33%	0.234 J	TFS1-H07-DP01 (15-16 ft)	0	0	700	130
1,2-Dibromoethane	c	12	0	0.00%	--		0	0	7	0.00002
1,1-Dichloroethane	c	12	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	12	0	0.00%	--		0	0	104	0.01
Ethylbenzene	c	12	1	8.33%	2	TFS1-H07-DP01 (15-16 ft)	0	0	1,000	10
Hexane	n	12	1	8.33%	0.501	TFS1-H07-DP01 (15-16 ft)	0	0	57	48
Isopropylbenzene	n	12	1	8.33%	0.423	TFS1-H07-DP01 (15-16 ft)	0	0	210	6.4
MTBE	c	12	0	0.00%	--		0	0	8,000	0.08
n-Propylbenzene	n	12	1	8.33%	0.834	TFS1-H07-DP01 (15-16 ft)	0	0	340	9.9
Styrene	n	12	0	0.00%	--		0	0	630	1.1
Tetrachloroethene	c	12	0	0.00%	--		0	0	8.6	0.023
Toluene	n	12	1	8.33%	0.712 JB	TFS1-H07-DP01 (15-16 ft)	0	0	5,000	40
1,1,1-Trichloroethane	n	12	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	12	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	12	1	8.33%	4.67	TFS1-H07-DP01 (15-16 ft)	0	1	6.2	0.24
1,3,5-Trimethylbenzene	n	12	2	16.67%	1.45	TFS1-H07-DP01 (15-16 ft)	0	1	78	1.2
m,p-Xylene	n	12	1	8.33%	7.56	TFS1-H07-DP01 (15-16 ft)	0	0	59	94.74
o-Xylene	n	12	1	8.33%	0.267 J	TFS1-H07-DP01 (15-16 ft)	0	0	69	100
Xylenes, Total	n	12	1	8.33%	7.79	TFS1-H07-DP01 (15-16 ft)	0	0	600	200

**TABLE 3.2-2. TANK FARM SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Acenaphthene	n	14	0	0.00%	--		0	0	4,000	200
Anthracene	n	14	0	0.00%	--		0	0	20,000	4,000
Benzo(a)anthracene	c	14	0	0.00%	--		0	0	50	10
Benzo(a)pyrene	c	14	0	0.00%	--		0	0	5	4
Benzo(b)fluoranthene	c	14	0	0.00%	--		0	0	50	50
Benzo(k)fluoranthene	c	14	0	0.00%	--		0	0	500	500
Bis(2-ethylhexyl)phthalate	c	14	0	0.00%	--		0	0	35	14
Chrysene	c	14	0	0.00%	--		0	0	5,000	2,000
Dibenz(a,h)acridine	--	14	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	14	0	0.00%	--		0	0	5	7
1,2-Dichlorobenzene	n	14	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	14	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	14	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	14	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	14	0	0.00%	--		0	0	120	4.5
Dimethylphthalate	--	14	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	14	0	0.00%	--		0	0	610	50.75
2,4-Dinitrophenol	n	14	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	14	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	14	0	0.00%	--		0	0	2,000	500
Fluorene	n	14	0	0.00%	--		0	0	2,000	600
Indene	--	14	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	14	0	0.00%	--		0	0	50	100
Tetraethyl Lead	n	3	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	14	1	7.14%	0.512	TFS1-H07-DP01 (15-16 ft)	0	1	16	0.051
2-Methylnaphthalene	n	14	1	7.14%	1.09	TFS1-H07-DP01 (15-16 ft)	0	0	23	4.4
2-Methylphenol	n	14	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	14	0	0.00%	--		0	0	610	44
Naphthalene	n	14	1	7.14%	1.56	TFS1-H07-DP01 (15-16 ft)	0	0	200	9
4-Nitrophenol	--	14	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	14	0	0.00%	--		0	0	NA	NA
Phenol	n	14	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	14	0	0.00%	--		0	0	2,000	4,000
Pyridine	n	14	0	0.00%	--		0	0	7.8	0.053
Quinoline	c	14	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	14	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.2-2. TANK FARM SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	14	1	7.14%	21.1	TFS1-H07-DP01 (15-16 ft)	0	0	500	200
C9-C10, Aromatic, Adjusted	n	14	2	14.29%	32.6 J	TFS1-H07-DP01 (15-16 ft)	0	0	1,000	400
C9-C12, Aliphatic, Adjusted	n	14	1	7.14%	41.7 J	TFS1-H07-DP01 (15-16 ft)	0	0	1,000	40,000
Total Extractable Hydrocarbons	n	14	0	0.00%	--		0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

JB - estimated concentration due to blank contamination

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.3-1. ASPHALT, SLAG, CINDER AREAS SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	64	15	23.44%	2.04 J	ASC08-S1-SS02 (0-0.5 ft)	0	0	15	3.1	2.7	0.368
Arsenic, Total	c	64	64	100.00%	23.6	ASC10-S1-SS02 (0-0.5 ft)	64	64	0	0.61	2.9	25.1
Barium, Total	n	64	64	100.00%	620 J	ASC02-S1-SS04 (0-0.5 ft)	0	2	2	1,500	414	392
Beryllium, Total	n	64	64	100.00%	1.04 JB	ASC02-COMP (0-0.5 ft)	0	0	24	16	32	0.817
Cadmium, Total	n	64	60	93.75%	1.59	ASC09-S1-SS06 (0-0.5 ft)	0	0	11	7	3.8	1.17
Chromium, Total	n	64	64	100.00%	58.7 J	ASC08-S1-SS02 (0-0.5 ft)	0	0	4	12,000	4,800,000	30.8
Cobalt, Total	n	64	64	100.00%	14.1	ASC08-S1-SS02 (0-0.5 ft)	64	64	5	2.3	2.4	9.13
Copper, Total	n	64	64	100.00%	83.3 J	ASC08-S1-SS02 (0-0.5 ft)	0	0	9	310	460	26.6
Cyanide, Total	n	64	2	3.13%	3.97	ASC09-COMP	0	0	0	4.7	20	NA
Lead, Total	L*	64	64	100.00%	1660	ASC11-COMP (0-0.5 ft)	2	4	33	400	440	30.2
Mercury, Total	n	64	62	96.88%	5.13 J	ASC09-S1-SS05 (0-0.5 ft)	2	0	13	2.3	NA	0.0837
Nickel, Total	n	64	64	100.00%	51.6 J	ASC08-S1-SS02 (0-0.5 ft)	0	0	1	150	447	32.6
Selenium, Total	n	64	30	46.88%	4.02	ASC05-S1-SS01 (0-0.5 ft)	0	4	1	39	2.6	2.09
Silver, Total	n	64	19	29.69%	0.972	ASC01-S1-SS03 (0-0.5 ft)	0	0	10	39	6	0.168
Vanadium, Total	n	64	64	100.00%	85.9	ASC10-S1-SS05 (0-0.5 ft)	59	0	18	39	780	63.9
Zinc, Total	n	64	64	100.00%	411	ASC10-S1-SS08 (0-0.5 ft)	0	0	5	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Benzene	c	108	4	3.70%	0.00329 J	ASC10-SS03 (1.5-2 ft)	0	0	1	0.04
2-Butanone	n	108	3	2.78%	0.0175 J	ASC10-SS03 (1.5-2 ft)	0	0	2,800	40
n-Butylbenzene	n	108	3	2.78%	0.0205 J	ASC10-SS01 (1.5-2 ft)	0	0	390	2.5
sec-Butylbenzene	n	108	3	2.78%	0.0182 J	ASC10-SS01 (1.5-2 ft)	0	0	780	4.6
tert-Butylbenzene	n	108	0	0.00%	--		0	0	780	1.1
Carbon Disulfide	n	108	0	0.00%	--		0	0	82	2.4
Chlorobenzene	n	108	0	0.00%	--		0	0	29	0.68
Chloroform	c	108	4	3.70%	0.00217 J	ASC05-SS02 (1.5-2 ft)	0	0	0.29	0.2
Cyclohexane	n	108	3	2.78%	0.106 J	ASC10-SS01 (1.5-2 ft)	0	0	700	430
1,2-Dibromoethane	c	108	0	0.00%	--		0	0	0.04	0.00002
1,1-Dichloroethane	c	108	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	108	0	0.00%	--		0	0	0.5	0.01
Ethylbenzene	c	108	3	2.78%	0.00552 J	ASC10-SS02 (1.5-2 ft)	0	0	6	10
Hexane	n	108	10	9.26%	0.0646 J	ASC10-SS03 (1.5-2 ft)	0	0	57	48
Isopropylbenzene	n	108	3	2.78%	0.00796 J	ASC10-SS01 (1.5-2 ft)	0	0	210	6.4
MTBE	c	108	0	0.00%	--		0	0	40	0.08
n-Propylbenzene	n	108	3	2.78%	0.0102 J	ASC10-SS01 (1.5-2 ft)	0	0	340	9.9
Styrene	n	108	0	0.00%	--		0	0	630	4.4
Tetrachloroethene	c	108	0	0.00%	--		0	0	8.6	0.023
Toluene	n	108	3	2.78%	0.00331 JB	ASC10-SS02 (1.5-2 ft)	0	0	600	40
1,1,1-Trichloroethane	n	108	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	108	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	108	3	2.78%	0.171 J	ASC10-SS01 (1.5-2 ft)	0	0	6.2	0.24
1,3,5-Trimethylbenzene	n	108	3	2.78%	0.137 J	ASC10-SS01 (1.5-2 ft)	0	0	78	4.2
m,p-Xylene	n	108	4	3.70%	0.0175 JB	ASC10-SS03 (1.5-2 ft)	0	0	59	94.74
o-Xylene	n	108	3	2.78%	0.0535 J	ASC10-SS01 (1.5-2 ft)	0	0	69	400
Xylenes, Total	n	108	4	3.70%	0.066 JB	ASC10-SS01 (1.5-2 ft)	0	0	70	200

**TABLE 3.3-1. ASPHALT, SLAG, CINDER AREAS SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs² (Surface Soil) (mg/kg)
Acenaphthene	n	64	0	0.00%	--		0	0	400	200
Anthracene	n	64	4	6.25%	1.85 J	ASC10-COMP (0-0.5 ft)	0	0	2,000	4,000
Benzo(a)anthracene	c	64	9	14.06%	2.39 J	ASC10-COMP (0-0.5 ft)	5	0	0.2	10
Benzo(a)pyrene	c	64	31	48.44%	4.56 J	ASC05-COMP (0-0.5 ft)	20	1	0.02	4
Benzo(b)fluoranthene	c	64	12	18.75%	1.84 J	ASC05-COMP (0-0.5 ft)	5	0	0.2	50
Benzo(k)fluoranthene	c	64	2	3.13%	0.033 J	ASC08-S1-SS01 (0-0.5 ft)	0	0	2	500
Bis(2-ethylhexyl)phthalate	c	64	0	0.00%	--		0	0	35	14
Chrysene	c	64	23	35.94%	6.4 J	ASC05-COMP (0-0.5 ft)	0	0	20	2,000
Dibenz(a,h)acridine	--	64	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	64	16	25.00%	1.41 J	ASC05-COMP (0-0.5 ft)	12	0	0.02	7
1,2-Dichlorobenzene	n	64	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	64	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	64	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	64	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	64	0	0.00%	--		0	0	120	4.5
Dimethylphthalate	--	64	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	64	0	0.00%	--		0	0	610	50.75
2,4-Dinitrophenol	n	64	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	64	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	64	6	9.38%	2.06 J	ASC05-COMP (0-0.5 ft)	0	0	300	500
Fluorene	n	64	2	3.13%	0.489 J	ASC01-COMP (0-0.5 ft)	0	0	300	600
Indene	--	64	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	64	20	31.25%	1.95 J	ASC05-COMP (0-0.5 ft)	8	0	0.2	100
Tetraethyl Lead	n	64	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	64	3	4.69%	1.95 J	ASC05-COMP (0-0.5 ft)	0	2	16	0.051
2-Methylnaphthalene	n	64	3	4.69%	1.63 J	ASC01-COMP (0-0.5 ft)	0	4	23	4.4
2-Methylphenol	n	64	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	64	0	0.00%	--		0	0	610	44
Naphthalene	n	64	0	0.00%	--		0	0	4	9
4-Nitrophenol	--	64	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	64	16	25.00%	11.7 J	ASC04-COMP (0-0.5 ft)	0	0	NA	NA
Phenol	n	64	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	64	27	42.19%	27.1 J	ASC05-COMP (0-0.5 ft)	0	0	200	4,000
Pyridine	n	64	0	0.00%	--		0	0	7.8	0.053
Quinoline	c	64	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	64	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.3-1. ASPHALT, SLAG, CINDER AREAS SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	108	4	3.70%	14.9 J	ASC10-SS03 (1.5-2 ft)	0	0	60	200
C9-C10, Aromatic, Adjusted	n	108	3	2.78%	53.9 J	ASC10-SS02 (1.5-2 ft)	0	0	100	100
C9-C12, Aliphatic, Adjusted	n	108	3	2.78%	88.9 J	ASC10-SS02 (1.5-2 ft)	0	0	100	10,000
C9-C18, Aliphatic, Adjusted	n	57	14	21.88%	2060	ASC10-COMP (0-0.5 ft)	4	0	200	50,000
C11-C22, Aromatic, Adjusted	n	57	34	53.13%	8470	ASC10-COMP (0-0.5 ft)	11	12	500	400
C19-C36, Aliphatic, Adjusted	n	57	38	59.38%	11900	ASC10-COMP (0-0.5 ft)	0	0	20,000	NA
Total Extractable Hydrocarbons	n	64	28	43.75%	31500 J	ASC10-COMP (0-0.5 ft)	0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

JB - estimated concentration due to blank contamination

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.3-2. ASPHALT, SLAG, CINDER AREAS SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	1	0	0.00%	--		0	0	1	3.1	2.7	0.368
Arsenic, Total	c	1	1	100.00%	15.4	ASC11-S1-SS05 (3.5-4 ft)	1	1	0	0.61	2.9	25.1
Barium, Total	n	1	1	100.00%	372	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	1,500	444	392
Beryllium, Total	n	1	1	100.00%	0.628 JB	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	16	32	0.817
Cadmium, Total	n	1	1	100.00%	0.642	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	7	3.8	1.17
Chromium, Total	n	1	1	100.00%	19	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	12,000	1,800,000	30.8
Cobalt, Total	n	1	1	100.00%	6.33	ASC11-S1-SS05 (3.5-4 ft)	1	1	0	2.3	2.1	9.13
Copper, Total	n	1	1	100.00%	14.9	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	310	460	26.6
Cyanide, Total	n	1	0	0.00%	--		0	0	0	4.7	20	NA
Lead, Total	L*	1	1	100.00%	8.32	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	400	140	30.2
Mercury, Total	n	1	1	100.00%	0.018 JB	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	2.3	NA	0.0837
Nickel, Total	n	1	1	100.00%	19.1	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	150	147	32.6
Selenium, Total	n	1	0	0.00%	--		0	0	0	39	2.6	2.09
Silver, Total	n	1	0	0.00%	--		0	0	1	39	6	0.168
Vanadium, Total	n	1	1	100.00%	37.2 J	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	39	700	63.9
Zinc, Total	n	1	1	100.00%	56.9	ASC11-S1-SS05 (3.5-4 ft)	0	0	0	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Benzene	c	1	0	0.00%	--		0	0	200	0.04
2-Butanone	n	1	0	0.00%	--		0	0	2,800	40
n-Butylbenzene	n	1	0	0.00%	--		0	0	390	2.5
sec-Butylbenzene	n	1	0	0.00%	--		0	0	780	4.6
tert-Butylbenzene	n	1	0	0.00%	--		0	0	780	1.1
Carbon Disulfide	n	1	0	0.00%	--		0	0	82	2.1
Chlorobenzene	n	1	0	0.00%	--		0	0	29	0.68
Chloroform	c	1	0	0.00%	--		0	0	0.29	0.2
Cyclohexane	n	1	0	0.00%	--		0	0	700	130
1,2-Dibromoethane	c	1	0	0.00%	--		0	0	7	0.00002
1,1-Dichloroethane	c	1	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	1	0	0.00%	--		0	0	104	0.01
Ethylbenzene	c	1	0	0.00%	--		0	0	1,000	10
Hexane	n	1	0	0.00%	--		0	0	57	18
Isopropylbenzene	n	1	0	0.00%	--		0	0	210	6.4
MTBE	c	1	0	0.00%	--		0	0	8,000	0.08
n-Propylbenzene	n	1	0	0.00%	--		0	0	340	9.9
Styrene	n	1	0	0.00%	--		0	0	630	1.1
Tetrachloroethene	c	1	0	0.00%	--		0	0	8.6	0.023
Toluene	n	1	0	0.00%	--		0	0	5,000	40
1,1,1-Trichloroethane	n	1	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	1	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	1	0	0.00%	--		0	0	6.2	0.24
1,3,5-Trimethylbenzene	n	1	0	0.00%	--		0	0	78	1.2
m,p-Xylene	n	1	0	0.00%	--		0	0	59	94.74
o-Xylene	n	1	0	0.00%	--		0	0	69	100
Xylenes, Total	n	1	0	0.00%	--		0	0	600	200

**TABLE 3.3-2. ASPHALT, SLAG, CINDER AREAS SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Acenaphthene	n	1	0	0.00%	--		0	0	4,000	200
Anthracene	n	1	0	0.00%	--		0	0	20,000	4,000
Benzo(a)anthracene	c	1	0	0.00%	--		0	0	50	10
Benzo(a)pyrene	c	1	0	0.00%	--		0	0	5	4
Benzo(b)fluoranthene	c	1	0	0.00%	--		0	0	50	50
Benzo(k)fluoranthene	c	1	0	0.00%	--		0	0	500	500
Bis(2-ethylhexyl)phthalate	c	1	0	0.00%	--		0	0	35	14
Chrysene	c	1	0	0.00%	--		0	0	5,000	2,000
Dibenz(a,h)acridine	--	1	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	1	0	0.00%	--		0	0	5	7
1,2-Dichlorobenzene	n	1	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	1	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	1	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	1	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	1	0	0.00%	--		0	0	120	4.5
Dimethylphthalate	--	1	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	1	0	0.00%	--		0	0	610	50.75
2,4-Dinitrophenol	n	1	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	1	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	1	0	0.00%	--		0	0	2,000	500
Fluorene	n	1	0	0.00%	--		0	0	2,000	600
Indene	--	1	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	1	0	0.00%	--		0	0	50	100
Tetraethyl Lead	n	1	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	1	0	0.00%	--		0	0	16	0.051
2-Methylnaphthalene	n	1	0	0.00%	--		0	0	23	4.4
2-Methylphenol	n	1	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	1	0	0.00%	--		0	0	610	44
Naphthalene	n	1	0	0.00%	--		0	0	200	9
4-Nitrophenol	--	1	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	1	0	0.00%	--		0	0	NA	NA
Phenol	n	1	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	1	0	0.00%	--		0	0	2,000	4,000
Pyridine	n	1	0	0.00%	--		0	0	7.8	0.053
Quinoline	c	1	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	1	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.3-2. ASPHALT, SLAG, CINDER AREAS SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	1	0	0.00%	--		0	0	500	200
C9-C10, Aromatic, Adjusted	n	1	0	0.00%	--		0	0	1,000	400
C9-C12, Aliphatic, Adjusted	n	1	0	0.00%	--		0	0	1,000	40,000
C9-C18, Aliphatic, Adjusted	n	1	1	100.00%	100	ASC11-S1-SS05 (3.5-4 ft)	0	0	2,000	50,000
C11-C22, Aromatic, Adjusted	n	1	1	100.00%	190	ASC11-S1-SS05 (3.5-4 ft)	0	0	4,000	400
C19-C36, Aliphatic, Adjusted	n	1	1	100.00%	790	ASC11-S1-SS05 (3.5-4 ft)	0	0	100,000	NA
Total Extractable Hydrocarbons	n	1	1	100.00%	1300	ASC11-S1-SS05 (3.5-4 ft)	0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

JB - estimated concentration due to blank contamination

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.4-1. TANK BERM 34 DOWNWIND AREAS SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	21	0	0.00%	--		0	0	0	3.1	2.7	0.368
Arsenic, Total	c	21	21	100.00%	22.1 J	ESPG-C1 (0.17-0.5 ft)	21	21	0	0.61	2.9	25.1
Barium, Total	n	21	21	100.00%	493 J	ESPG-C1 (1.5-2 ft)	0	2	2	1,500	444	392
Beryllium, Total	n	21	21	100.00%	1.11 JB	TB34-DW08 (0.17-0.5 ft)	0	0	10	16	32	0.817
Cadmium, Total	n	21	20	95.24%	0.445 J	TB34-DW16 (0-0.17 ft)	0	0	0	7	3.8	1.17
Chromium, Total	n	21	21	100.00%	29.9 J	TB34-DW08 (0.17-0.5 ft)	0	0	0	12,000	1,800,000	30.8
Cobalt, Total	n	21	21	100.00%	8.21	TB34-DW16 (0.5-1 ft)	21	24	0	2.3	2.1	9.13
Copper, Total	n	21	21	100.00%	54.9 J	TB34-DW16 (0-0.17 ft)	0	0	1	310	460	26.6
Cyanide, Total	n	5	1	20.00%	0.505 J	HSFF-D2 (0-0.17 ft)	0	0	0	4.7	20	NA
Lead, Total	L*	21	21	100.00%	107 J	TB34-DW08 (0-0.17 ft)	0	0	2	400	140	30.2
Mercury, Total	n	21	19	90.48%	0.0788 JB	TB34-DW-23 (0-0.5 ft)	0	0	0	2.3	NA	0.0837
Nickel, Total	n	21	21	100.00%	25.9	ESPG-C1 (0.5-1 ft)	0	0	0	150	147	32.6
Selenium, Total	n	21	9	42.86%	1.86 J	HSFF-D2 (1.5-2 ft)	0	0	0	39	2.6	2.09
Silver, Total	n	21	8	38.10%	0.348 J	TB34-DW16 (0.5-1 ft)	0	0	8	39	6	0.168
Vanadium, Total	n	21	21	100.00%	76.3 J	TB34-DW08 (0.17-0.5 ft)	18	0	2	39	780	63.9
Zinc, Total	n	21	21	100.00%	100	TB34-DW16 (0-0.17 ft)	0	0	0	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Benzene	c	5	1	20.00%	0.000736 J	ESPG-C1 (1.5-2 ft)	0	0	1	0.04
2-Butanone	n	5	0	0.00%	--		0	0	2,800	40
n-Butylbenzene	n	5	0	0.00%	--		0	0	390	2.5
sec-Butylbenzene	n	5	0	0.00%	--		0	0	780	4.6
tert-Butylbenzene	n	5	0	0.00%	--		0	0	780	1.1
Carbon Disulfide	n	5	0	0.00%	--		0	0	82	2.1
Chlorobenzene	n	5	0	0.00%	--		0	0	29	0.68
Chloroform	c	5	0	0.00%	--		0	0	0.29	0.2
Cyclohexane	n	5	0	0.00%	--		0	0	700	130
1,2-Dibromoethane	c	5	0	0.00%	--		0	0	0.04	0.00002
1,1-Dichloroethane	c	5	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	5	0	0.00%	--		0	0	0.5	0.01
Ethylbenzene	c	5	0	0.00%	--		0	0	6	10
Hexane	n	5	0	0.00%	--		0	0	57	48
Isopropylbenzene	n	5	0	0.00%	--		0	0	210	6.4
MTBE	c	5	0	0.00%	--		0	0	40	0.08
n-Propylbenzene	n	5	0	0.00%	--		0	0	340	9.9
Styrene	n	5	0	0.00%	--		0	0	630	1.1
Tetrachloroethene	c	5	0	0.00%	--		0	0	8.6	0.023
Toluene	n	5	0	0.00%	--		0	0	600	40
1,1,1-Trichloroethane	n	5	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	5	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	5	0	0.00%	--		0	0	6.2	0.24
1,3,5-Trimethylbenzene	n	5	0	0.00%	--		0	0	78	1.2
m,p-Xylene	n	5	0	0.00%	--		0	0	59	94.74
o-Xylene	n	5	0	0.00%	--		0	0	69	100
Xylenes, Total	n	5	0	0.00%	--		0	0	70	200

**TABLE 3.4-1. TANK BERM 34 DOWNWIND AREAS SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
Acenaphthene	n	5	0	0.00%	--		0	0	400	200
Anthracene	n	5	0	0.00%	--		0	0	2,000	4,000
Benzo(a)anthracene	c	5	0	0.00%	--		0	0	0.2	10
Benzo(a)pyrene	c	5	2	40.00%	0.0106 J	ESPG-C1 (0-0.17 ft)	0	0	0.02	4
Benzo(b)fluoranthene	c	5	1	20.00%	0.0039 J	TB34-DW-23 (0-0.5 ft)	0	0	0.2	50
Benzo(k)fluoranthene	c	5	0	0.00%	--		0	0	2	500
Bis(2-ethylhexyl)phthalate	c	5	1	20.00%	1 J	ESPG-C1 (0-0.17 ft)	0	0	35	14
Chrysene	c	5	0	0.00%	--		0	0	20	2,000
Dibenz(a,h)acridine	--	5	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	5	1	20.00%	0.00628 J	ESPG-C1 (0-0.17 ft)	0	0	0.02	7
1,2-Dichlorobenzene	n	5	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	5	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	5	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	5	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	5	0	0.00%	--		0	0	120	4.5
Dimethylphthalate	--	5	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	5	2	40.00%	0.134 J	TB34-DW16 (0-0.17 ft)	0	0	610	50.75
2,4-Dinitrophenol	n	5	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	5	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	5	0	0.00%	--		0	0	300	600
Fluorene	n	5	0	0.00%	--		0	0	300	600
Indene	--	5	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	5	0	0.00%	--		0	0	0.2	100
Tetraethyl Lead	n	5	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	5	0	0.00%	--		0	0	16	0.051
2-Methylnaphthalene	n	5	0	0.00%	--		0	0	23	4.4
2-Methylphenol	n	5	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	5	0	0.00%	--		0	0	610	44
Naphthalene	n	5	0	0.00%	--		0	0	4	0
4-Nitrophenol	--	5	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	5	1	20.00%	0.0038 J	TB34-DW-23 (0-0.5 ft)	0	0	NA	NA
Phenol	n	5	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	5	0	0.00%	--		0	0	200	4,000
Pyridine	n	5	0	0.00%	--		0	0	7.8	0.053
Quinoline	c	5	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	5	0	0.00%	--		0	0	7.8	0.086

**TABLE 3.4-1. TANK BERM 34 DOWNWIND AREAS SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Carbon Fractions	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency ⁴	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Surface Soil) SL Exceedances	MTGW SL ² (Surface Soil) Exceedances	Direct Contact (Surface Soil) SLs (mg/kg)	MTGW SLs ² (Surface Soil) (mg/kg)
C5-C8, Aliphatic, Adjusted	n	5	0	0.00%	--		0	0	60	200
C9-C10, Aromatic, Adjusted	n	5	0	0.00%	--		0	0	100	100
C9-C12, Aliphatic, Adjusted	n	5	0	0.00%	--		0	0	100	10,000
Total Extractable Hydrocarbons	n	5	0	0.00%	--		0	0	NA	NA

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

JB - estimated concentration due to blank contamination

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.5-1. PIPELINE CORRIDOR SURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Inorganic Constituents												
Lead, Total	L*	2	2	100.00%	145 J	PCS1-Q12-DP01 (0-0.5 ft)	0	4	1	400	440	30.2

Notes:

¹ - "c" indicates constituent is a carcinogen; "n" indicates non-carcinogen; "--" indicates constituent not included in classification system. "L*" indicates that lead is handled as a special case, per MDEQ and U.S. EPA. Classification per U.S. EPA RSL Table (5/2013).

² - Evaluation presented in the text and on the summary maps assumes that site groundwater will be classified as Class IV Groundwater. In Class IV Groundwater, MTGW SLs apply only to carcinogens.

³ - MDEQ-approved background values (as presented in June 3, 2013 submittal by CEMC). For some constituents, the background concentrations exceed the SLs; in those cases, the background concentrations are used as the screening criteria.

⁴ - Samples analyzed for T.E.H. are re-analyzed for the individual heavier hydrocarbon fractions (C9-C18, C11-C22, C19-C36) only if the T.E.H. concentration is greater than 200 mg/kg. Therefore, the detection frequency for the three heavier fractions is calculated using the total number of T.E.H. samples.

~~strikethrough font~~ - indicates that the SL is not applicable to the constituent

bold-oversized font - indicates the SL that is applicable to the constituent (applies to inorganics only)

ft-bgs - feet below ground surface

J - estimated concentration

mg/kg - milligrams per kilogram

MTGW - migration to groundwater

NA - not available

SL - screening level determined via MDEQ flowchart procedures

surface soil / subsurface soil: "surface soil" is defined as a sample collected at a depth of 2 ft-bgs or shallower; samples collected from greater depths are defined as "subsurface soil"

T.E.H. - total extractable hydrocarbons

-- not applicable

**TABLE 3.5-2. PIPELINE CORRIDOR SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Inorganic Constituents	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact SL Exceedances	MTGW SL Exceedances ²	Site-Specific Background Value ³ Exceedances	Direct Contact SLs (mg/kg)	MTGW SLs ² (mg/kg)	Site-Specific Background Values ³ (mg/kg)
Antimony, Total	n	69	10	14.49%	1.55 J	PC-M10-DP01 (4-6 ft)	1	4	69	3.1	2.7	0.368
Arsenic, Total	c	69	69	100.00%	43.4	PC-O07-DP01 (4-6 ft)	69	69	1	0.61	2.9	25.1
Barium, Total	n	69	69	100.00%	432 J	PC-L06-DP01 (4-6 ft)	0	4	2	1,500	414	392
Beryllium, Total	n	69	69	100.00%	2.81 JB	PC-L06-DP01 (4-6 ft)	0	0	41	16	32	0.817
Cadmium, Total	n	69	69	100.00%	0.874	PC-J09-DP02 (4-6 ft)	0	0	0	7	3.8	1.17
Chromium, Total	n	69	69	100.00%	36.8 J	PC-H09-DP02 (4-6 ft)	0	0	3	12,000	1,800,000	30.8
Cobalt, Total	n	69	69	100.00%	14.3	PC-K06-DP01 (4-6 ft)	69	69	7	2.3	2.1	9.13
Copper, Total	n	69	69	100.00%	44.6 J	PC-O08-DP01 (4-6 ft)	0	0	1	310	460	26.6
Cyanide, Total	n	69	3	4.35%	0.268 J	PC-O08-DP01 (4-6 ft)	0	0	0	4.7	20	NA
Lead, Total	L*	69	69	100.00%	117 J	PC-M08-DP02 (2-4 ft)	0	0	2	400	140	30.2
Mercury, Total	n	69	62	89.86%	2.17	PC-O08-DP01 (4-6 ft)	0	0	2	2.3	NA	0.0837
Nickel, Total	n	69	69	100.00%	31.9	PC-M08-DP01 (4-6 ft)	0	0	0	150	147	32.6
Selenium, Total	n	69	18	26.09%	3.45	PC-L08-DP01 (4-6 ft)	0	2	2	39	2.6	2.09
Silver, Total	n	69	10	14.49%	0.31 J	PC-L06-DP01 (4-6 ft)	0	0	69	39	6	0.168
Vanadium, Total	n	69	69	100.00%	87.2 J	PC-H09-DP02 (4-6 ft)	58	0	14	39	780	63.9
Zinc, Total	n	69	69	100.00%	120	PC-H09-DP02 (4-6 ft)	0	0	1	2,300	2,900	119

** - see Section 3.1 of the report for discussion of the project approach to arsenic, cobalt, and vanadium.

Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Benzene	c	69	4	5.80%	0.0459 J	PC-N08-DP02 (12-14 ft)	0	3	200	0.04
2-Butanone	n	68	0	0.00%	--		0	0	2,800	40
n-Butylbenzene	n	69	4	5.80%	1.04	PC-I08-DP01 (10 ft)	0	0	390	2.5
sec-Butylbenzene	n	69	7	10.14%	4.14	PC-I08-DP01 (10 ft)	0	0	780	4.6
tert-Butylbenzene	n	69	4	5.80%	0.173 J	PC-I08-DP01 (10 ft)	0	0	780	1.1
Carbon Disulfide	n	69	1	1.45%	0.0012 J	PC-Q13-DP01 (6-8 ft)	0	0	82	2.1
Chlorobenzene	n	69	0	0.00%	--		0	0	29	0.68
Chloroform	c	69	0	0.00%	--		0	0	0.29	0.2
Cyclohexane	n	69	1	1.45%	0.104 J	PC-N08-DP02 (12-14 ft)	0	0	700	130
1,2-Dibromoethane	c	69	0	0.00%	--		0	0	7	0.00002
1,1-Dichloroethane	c	69	0	0.00%	--		0	0	3.3	0.0068
1,2-Dichloroethane	c	69	0	0.00%	--		0	0	104	0.01
Ethylbenzene	c	69	8	11.59%	8.48	PC-G06-DP01 (10 ft)	0	0	1,000	10
Hexane	n	69	11	15.94%	0.054 J	PC-N08-DP02 (12-14 ft)	0	0	57	18
Isopropylbenzene	n	69	7	10.14%	3.22	PC-I08-DP01 (10 ft)	0	0	210	6.4
MTBE	c	69	0	0.00%	--		0	0	8,000	0.08
n-Propylbenzene	n	69	7	10.14%	5.64	PC-I08-DP01 (10 ft)	0	0	340	9.9
Styrene	n	69	0	0.00%	--		0	0	630	1.1
Tetrachloroethene	c	69	0	0.00%	--		0	0	8.6	0.023
Toluene	n	69	1	1.45%	0.00344 JB	PC-N08-DP02 (12-14 ft)	0	0	5,000	40
1,1,1-Trichloroethane	n	69	0	0.00%	--		0	0	870	0.7
Trichloroethene	c	69	0	0.00%	--		0	0	0.44	0.018
1,2,4-Trimethylbenzene	n	69	5	7.25%	11.5	PC-I08-DP01 (10 ft)	1	3	6.2	0.24
1,3,5-Trimethylbenzene	n	69	5	7.25%	12.7	PC-I08-DP01 (10 ft)	0	2	78	1.2
m,p-Xylene	n	69	4	5.80%	6.33	PC-I08-DP01 (10 ft)	0	0	59	94.74
o-Xylene	n	69	3	4.35%	0.426	PC-I08-DP01 (10 ft)	0	0	69	100
Xylenes, Total	n	69	4	5.80%	6.67	PC-I08-DP01 (10 ft)	0	0	600	200

**TABLE 3.5-2. PIPELINE CORRIDOR SUBSURFACE SOIL DATA SUMMARY
PHASE II REMEDIAL INVESTIGATION REPORT
FORMER TEXACO SUNBURST WORKS REFINERY, SUNBURST, MONTANA**

Semi-Volatile Organic Compounds	Carcinogen or Non-Carcinogen ¹	Number of Samples	Detect Count	Detection Frequency	Maximum Detected Concentration (mg/kg)	Location of Maximum Detected Concentration	Direct Contact (Subsurface Soil) SL Exceedances	MTGW SL ² (Subsurface Soil) Exceedances	Direct Contact (Subsurface Soil) SLs (mg/kg)	MTGW SLs ² (Subsurface Soil) (mg/kg)
Acenaphthene	n	69	1	1.45%	0.11 J	PC-I08-DP01 (10 ft)	0	0	4,000	200
Anthracene	n	69	1	1.45%	0.0971 J	PC-G07-DP01 (10 ft)	0	0	20,000	4,000
Benzo(a)anthracene	c	69	1	1.45%	0.0797 J	PC-G06-DP02 (10 ft)	0	0	50	10
Benzo(a)pyrene	c	69	10	14.49%	0.0521 J	PC-G06-DP01 (10 ft)	0	0	5	4
Benzo(b)fluoranthene	c	69	0	0.00%	--		0	0	50	50
Benzo(k)fluoranthene	c	69	0	0.00%	--		0	0	500	500
Bis(2-ethylhexyl)phthalate	c	69	4	5.80%	0.186 J	PC-P13-DP01 (2-4 ft)	0	0	35	14
Chrysene	c	69	6	8.70%	0.206	PC-G06-DP01 (10 ft)	0	0	5,000	2,000
Dibenz(a,h)acridine	--	69	0	0.00%	--		0	0	NA	NA
Dibenzo(a,h)anthracene	c	69	6	8.70%	0.0123 J	PC-G06-DP02 (10 ft)	0	0	5	7
1,2-Dichlorobenzene	n	69	0	0.00%	--		0	0	190	5.8
1,3-Dichlorobenzene	--	69	0	0.00%	--		0	0	NA	NA
1,4-Dichlorobenzene	c	69	0	0.00%	--		0	0	2.4	0.72
Diethylphthalate	n	69	0	0.00%	--		0	0	4,900	72.64
2,4-Dimethylphenol	n	69	0	0.00%	--		0	0	120	4.5
Dimethylphthalate	--	69	0	0.00%	--		0	0	NA	NA
Di-n-butylphthalate	n	69	0	0.00%	--		0	0	610	50.75
2,4-Dinitrophenol	n	69	0	0.00%	--		0	0	12	0.782
1,4-Dioxane	c	69	0	0.00%	--		0	0	4.9	0.0014
Fluoranthene	n	69	0	0.00%	--		0	0	2,000	500
Fluorene	n	69	5	7.25%	0.849 J	PC-Q13-DP01 (6-8 ft)	0	0	2,000	600
Indene	--	69	0	0.00%	--		0	0	NA	NA
Indeno(1,2,3-cd)pyrene	c	69	0	0.00%	--		0	0	50	100
Tetraethyl Lead	n	69	0	0.00%	--		0	0	0.00061	0.000035
1-Methylnaphthalene	c	69	7	10.14%	5.17 J	PC-N08-DP02 (12-14 ft)	0	7	16	0.051
2-Methylnaphthalene	n	69	5	7.25%	8.27	PC-N08-DP02 (12-14 ft)	0	5	23	4.4
2-Methylphenol	n	69	0	0.00%	--		0	0	310	5.8
4-Methylphenol	n	69	0	0.00%	--		0	0	610	44
Naphthalene	n	69	6	8.70%	6.54 J	PC-N08-DP02 (12-14 ft)	0	0	200	9
4-Nitrophenol	--	69	0	0.00%	--		0	0	NA	NA
Phenanthrene	--	69	7	10.14%	1.2 J	PC-Q13-DP01 (6-8 ft)	0	0	NA	NA
Phenol	n	69	0	0.00%	--		0	0	1,800	4.73
Pyrene	c	69	4	5.80%	0.097 J	PC-G06-DP01 (10 ft)	0	0	2,000	4,000
Pyridine	n	69	1	1.45%	0.111 J	PC-N08-DP02 (12-14 ft)	0	4	7.8	0.053
Quinoline	c	69	0	0.00%	--		0	0	0.16	0.00068
Thiophenol	n	69	0	0.00%	--		0	0	7.8	0.086