

**FINAL**  
**REMEDIAL INVESTIGATION REPORT**  
**KALISPELL POLE AND TIMBER, RELIANCE REFINERY,**  
**AND YALE OIL FACILITIES**

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Prepared for:

**MONTANA DEPARTMENT OF ENVIRONMENTAL QUALITY**  
**Remediation Division**  
P.O. Box 200901  
Helena, Montana 59620

Prepared by:

**TETRA TECH EM INC.**  
Power Block Building, Suite 612  
7 West 6<sup>th</sup> Avenue  
Helena, Montana 59601  
(406) 442-5588

Final Draft Remedial Investigation prepared by Tetra Tech EM, Inc. in July 2007; Final Remedial Investigation prepared by the Montana Department of Environmental Quality

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## ACRONYMS AND ABBREVIATIONS

°C	Degrees Celsius
°F	Degrees Fahrenheit
µg/dL	Micrograms per deciliter
µg/L	Micrograms per liter
µm	Micrometers
AES	Applied Earth Sciences, Inc.
AST	Aboveground storage tank
atm-m <sup>3</sup> /mol	Atmospheres per cubic meter per mole
ATSDR	Agency for Toxic Substances and Disease Registry
B(a)P	Benzo(a)pyrene
BCF	Bioconcentration factors
BTEX	Benzene-toluene-ethylbenzene-xylene
bgs	Below ground surface
BNSF	BNSF Railway Company
CDD	Chlorinated dibenzo-p-dioxins
CDF	Polychlorinated dibenzofurans
CECRA	Montana Comprehensive Environmental Cleanup and Responsibility Act
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CERCLIS	Comprehensive Environmental Response, Compensation, and Liability Information System
CFR	Code of Federal Regulations
COPC	Contaminant of potential concern
CSM	Conceptual site model
DAF	Dilution attenuation factor
DEQ	Montana Department of Environmental Quality
DNAPL	Dense nonaqueous phase liquid
DNRC	Montana Department of Natural Resources and Conservation
DO	Dissolved oxygen
DQO	Data quality objective
DRO	Diesel-range organics
DSR	Data summary report
ELI	Energy Laboratories, Inc.
EPA	U.S. Environmental Protection Agency
EPH	Extractable petroleum hydrocarbons
°F	Degrees Fahrenheit
FEMA	Federal Emergency Management Agency
FID	Flame ionization detector
FIT	Field Investigation Team
FS	Feasibility study
FSP	Field sampling plan
ft/day	Feet per day
ft <sup>2</sup> /day	Foot squared per day
ft <sup>3</sup> /s	Cubic feet per second

**ACRONYMS AND ABBREVIATIONS**  
**(Continued)**

g/mL	Grams per milliliter
GAC	Granulated activated carbon
GC/MS	Gas chromatograph/mass spectrometer
gpm	Gallons per minute
GPS	Global positioning system
HDPE	High density polyethylene
HRA	Historical Research Associates, Inc
HRS	Hazard Ranking System
HSA	Hollow-stem auger
ID	Inside diameter
IDW	Investigation-derived waste
K <sub>oc</sub>	Organic carbon partition coefficient
KPT	Kalispell Pole and Timber
KRY	Kalispell Pole and Timber (KPT) Facility, Reliance Refinery Company (Reliance) Facility, and Yale Oil Corporation (Yale Oil) Facility
LCS	Laboratory control sample
LNAPL	Light nonaqueous phase liquids
MDL	Method detection limit
MDHES	Montana Department of Health and Environmental Sciences
mg/kg	Milligrams per kilogram
mg/L	Milligrams per liter
mm Hg	Millimeters of mercury
MS/MSD	Matrix spike and matrix spike duplicate
NAD	Montana State Plane Coordinates North American Datum 1983
NAVD	National Geodetic Vertical Datum 1988
NAPL	Nonaqueous phase liquid
ng/kg	Nanograms per kilogram
NRIS	Montana Natural Resource Information System
NSC	National Safety Council
NSF	National Science Foundation
OH	Hydroxyl
ORP	Oxidation-reduction potential
P&E	Proper and expeditious
PAH	Polycyclic aromatic hydrocarbons
PCB	Polychlorinated biphenyls
PCP	Pentachlorophenol
pg/L	Picograms per liter
PID	Photoionization detector
PLP	Potentially liable persons\
PM <sub>10</sub>	Fine particulate matter
ppm	Parts per million
PRG	Preliminary remediation goal
psi	Pounds per square inch
PTS	Pioneer Technical Services, Inc.
PVC	Polyvinyl chloride

**ACRONYMS AND ABBREVIATIONS**  
**(Continued)**

QA	Quality assurance
QAPP	Quality assurance project plan
QC	Quality control
RAGS	Risk Assessment Guidance for Superfund
RAIS	Risk Assessment Information System
RBCA	Risk-based corrective action
RBSL	Risk-based screening level
RCRA	Resource Conservation and Recovery Act
Reliance	Reliance Refinery Company
RETEC	Remediation Technologies, Inc.
RI	Remedial investigation
RI/FS	Remedial investigation/feasibility study
RIWP	Remedial investigation work plan
SAP	Sampling and analysis plan
SC	Specific conductance
SOP	Standard operating procedure
SPLP	Synthetic precipitation leaching procedure
SQL	Sample quantitation limit
SSL	Soil screening level
SVOC	Semivolatile organic compounds
2,3,7,8-TCDD	2,3,7,8-Tetrachlordibenzo-p-dioxin
TCLP	Toxicity characteristics leaching procedure
TEF	Toxicity equivalency factor
TEQ	Toxicity equivalency quotient
ThermoRetec	ThermoRetec Consulting Corporation
TOC	Total organic carbon
TSD	Treatment, storage, and disposal
TtEMI	Tetra Tech EM Inc.
TPH	Total petroleum hydrocarbons
TPH-e	Total petroleum hydrocarbons-extractable
UDIG	Montana One Call utility clearance
USCS	Unified Soil Classification System
USDA	U.S. Department of Agriculture
USGS	U.S. Geological Survey
VCRA	Voluntary Cleanup and Redevelopment Act
VOA	Volatile organic analysis
VOC	Volatile organic compound
VPH	Volatile petroleum hydrocarbons
WHO	World Health Organization
WRCC	Western Regional Climate Center
WRI	Western Research Institute
Yale Oil	Yale Oil Corporation

## **EXECUTIVE SUMMARY**

The Kalispell Pole and Timber (KPT) Facility, Reliance Refinery Company (Reliance) Facility, the Yale Oil Corporation (Yale Oil) Facility, collectively referred to as the KRY Site, occupies an area of approximately 55 acres located on the northeastern edge of the City of Kalispell, Montana. The three facilities are in relatively close proximity to each other and are located adjacent to the Stillwater River and nearby residential areas. This remedial investigation (RI) for the KRY Site has been prepared by Tetra Tech EM Inc. (TTEMI), for the Montana Department of Environmental Quality (DEQ) Remediation Division (RD). DEQ/RD is the lead agency in charge of conducting a remedial investigation and feasibility study (RI/FS) at the site.

Groundwater contamination from each of these facilities is commingled in the shallow aquifer. Contaminants in soil and groundwater include semi-volatile organic compounds (SVOCs) including pentachlorophenol (PCP), polycyclic aromatic hydrocarbons (PAHs), dioxins and furans, volatile organic compounds (VOCs), petroleum hydrocarbons, and metals, most notably lead.

This RI was conducted to (1) identify, characterize, and define the extent of contaminant sources, (2) delineate the nature and extent of the contamination in soils and groundwater, (3) collect data necessary to prepare baseline risks to human health and the environment; and (4) collect site-specific data necessary to develop and evaluate viable remedial alternatives.

Below is a summary of the site history and RI Report results followed by conclusions and recommendations.

### **Site History**

Site assessment activities were conducted by the U.S. Environmental Protection Agency (EPA) and the Montana Department of Health and Environmental Services (predecessor to the Montana Department of Environmental Quality [DEQ]) at the three facilities from 1985 to 1996. Investigations were conducted to characterize contamination in soils, sludge, and groundwater and to gather historical data for possible Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) remediation. A draft hazard ranking score (HRS) package was developed for the KPT and Reliance facilities, which indicated that the facilities were candidates for the federal National Priorities List (NPL).

The results of previous investigations identify three potential source areas (KPT, Reliance, and Yale Oil) where elevated concentrations of contaminants of potential concern (COPC) are found in soil and

associated groundwater. In addition, the investigations identified concentrations of contaminants in groundwater throughout the KRY Site that exceeded state standards and that pose a potential threat to human health and the environment.

KPT is a former wood treating facility that operated from approximately 1945 to 1990. The facility encompasses approximately 35 acres. Spills or leaks of wood treating oil that contained PCP from the treatment vats, aboveground storage tanks, and treated wood contaminated on-site soils and groundwater with PCP, dioxins and furans, PAHs, and diesel-range petroleum hydrocarbons.

Reliance is a former oil refinery that operated from 1924 to the 1960s. The facility encompasses approximately 7 acres. On-site disposal of sludge, leaks of sludge and oil from aboveground storage tanks, and off-loading of crude oil contaminated soil with petroleum hydrocarbons and some metals, notably lead. Groundwater beneath the Reliance facility is contaminated with petroleum hydrocarbons, PCP, dioxins and furans, and PAHs.

The Yale Oil Facility is a former petroleum bulk plant and product refinery that operated from 1938 to 1978. The facility encompasses approximately 2.3 acres. Leaks and possible spills from aboveground storage tanks and other facilities contaminated on-site soils and groundwater. Thermal desorption, using a permitted unit, was conducted on the soils to remove petroleum hydrocarbon contamination. Groundwater beneath the facility is contaminated with PCP, dioxins and furans, and petroleum hydrocarbons.

### **Geology and Hydrogeology**

The KPT, Reliance, and Yale Oil facilities are all located in proximity to and south and west of the Stillwater River. The area in the vicinity of the KRY Site is a relatively flat, broad floodplain that is composed of Quaternary age materials ranging from clay- to cobble-sized materials. The dominant lithology at the site is silty gravel and gravelly silty sand. Also present are intervals of clay, silt, silty fine- to medium-grained sand, and fine- to coarse-grained sand. Cobbles are present throughout the site within various lithologies but are generally found within the sandy gravel and gravelly sand.

Three distinctive hydrostratigraphic units are present at the KRY Site. From the ground surface downward, these units can be described as (1) an unconfined aquifer composed of unconsolidated alluvium, (2) a low-permeability confining unit composed of clayey gravelly silt and silty clay at the base of the unconfined aquifer, and (3) a confined aquifer system composed of unconsolidated alluvium

underlying the low-permeability unit. Drilling during this RI or previous investigations did not penetrate the top of the confined aquifer.

Groundwater at the KRY Site is typically encountered at depths between 10 to 25 feet below ground surface. Groundwater level measurements indicate that groundwater flow is generally from west to east in both the upper and lower portions of the unconfined aquifer. The overall site-wide horizontal groundwater gradient is approximately 0.0056 feet/foot in the unconfined aquifer.

Although the lower portion of the unconfined aquifer shows a relatively constant gradient from west to east, two areas of apparent groundwater mounding are identified in the upper portion of the unconfined aquifer. One area of groundwater mounding is located on the Reliance facility. Another area of groundwater mounding is present in the vicinity of the Office Max, Rocky Mountain Marine, and Town Pump properties. The two groundwater mounds show steeper gradients and varying directions of groundwater flow in these areas of the upper portion of the unconfined aquifer.

Aquifer test results obtained during this RI and from previous investigations are similar. They indicate that hydraulic conductivities of the aquifer vary throughout the site and are representative of silty fine sand, clean sand, and gravelly sand lithologies. Short term aquifer tests conducted during this RI showed aquifer hydraulic conductivities to range from 17 to 326 feet/day.

### **Nature and Extent of Contamination**

Media that were sampled during the RI include groundwater, surface soil, subsurface soil, surface water, and sediment. The RI considered analytes as contaminants of potential concern (COPCs) if they exceed screening levels or have no screening levels, were present in more than 5 percent of the samples at concentrations above laboratory detection limits, were present above background concentrations, and they are not laboratory standards (and not found at the site) or essential nutrients. Additionally, analytes are considered COPCs if they have no screening levels and meet any of the other criteria listed above.

In total, 31 analytes are considered COPCs for groundwater, 39 analytes are considered COPCs for surface soil, and 46 analytes are considered COPCs for subsurface soil. In addition, one analyte is considered a COPCs for surface water and no analytes are considered COPCs for sediment. Analytes include individual compounds (such as PCP) and groups of compounds (such as C11 through C12 aromatic hydrocarbons).

Based on the identification of COPCs and comparison to screening criteria, specific COPCs were selected for further discussion and presentation in the RI report based on their frequency of detection and incidence above screening levels. Selected COPCs for groundwater include PCP, dioxins and furans, benzene, 1,2,4-trimethylbenzene, and C9-C10 aromatic hydrocarbons. COPCs for surface soil include PCP, dioxins and furans, benzo(a)pyrene, lead, and C11-C22 aromatic hydrocarbons. COPCs for subsurface soil include PCP, dioxins and furans, benzo(a)pyrene, lead, and C9-C18 aromatic hydrocarbons. Selected COPCs for surface water are dioxins and furans. No COPCs were selected for further discussion or presentation for sediment because no compounds exceeded screening criteria..

## **Groundwater**

Groundwater samples were collected in select monitoring wells, residential wells, industrial wells, and public water supply wells at the KRY Site and nearby vicinity during the RI sampling event in July and August 2006. No contaminants were found in industrial, residential, or public supply wells at concentrations exceeding EPA's maximum contaminant levels allowed under the Safe Drinking Water Act. Twenty-two chemicals were detected in groundwater monitoring well samples at concentrations above the screening criteria (DEQ human health standard, the DEQ RBSL, or the EPA Region 9 tap water PRG), as summarized in Table 4-1. In addition, groundwater from some monitoring wells located in the upper portion of the unconfined aquifer contained measurable light nonaqueous phase liquids.

Four SVOCs (PCP, bis[2-ethylhexyl]phthalate, 2,4,6-trichlorophenol, and naphthalene) were detected in groundwater samples at maximum concentrations that exceeded screening criteria. Pentachlorophenol was detected in samples from 27 monitoring wells located in the upper portion of the unconfined aquifer and four monitoring wells located in the lower portion of the unconfined aquifer with concentrations ranging from 0.036J micrograms per liter ( $\mu\text{g/L}$ ) to 16,300  $\mu\text{g/L}$ . The highest concentrations of PCP within the upper portion of the unconfined aquifer are located within and immediately downgradient of the KPT facility, suggesting that the KPT facility is the primary source area for PCP.

Dioxins and furans (2,3,7,8-TCDD toxicity equivalency quotient [TEQ]) were detected in all groundwater samples at maximum concentrations that exceeded the screening criteria. Calculated 2,3,7,8-TCDD TEQ values range from 2.7 picograms per liter ( $\text{pg/L}$ ) to 1,275  $\text{pg/L}$ . Background concentrations of 2,3,7,8-TCDD TEQ were measured in an upgradient monitoring well at 5.58  $\text{pg/L}$ . The highest concentrations of 2,3,7,8-TCDD TEQ within the upper portion of the unconfined aquifer are located within and immediately downgradient of the KPT facility, indicating that the KPT facility is the primary source area for dioxins and furans in groundwater.

Twelve VOCs were detected in groundwater samples at maximum concentrations that exceeded the screening criteria (Table 4-1). Seven of these compounds are considered COPCs for groundwater: benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 4-isopropyltoluene, ethylbenzene, n-butylbenzene, and toluene. No tetraethyllead was detected in groundwater samples. No VOCs were detected in the upgradient (background) monitoring well KRY101A.

The highest concentration of benzene within the upper unconfined aquifer was detected in monitoring well NTL-MW-4 (646 µg/L), installed during a Phase I environmental site assessment and not as part of this RI, and located in the southern portion of the Seaman Shelton site (near Northern Energy Propane), southwest of Wal-Mart. Benzene was also detected in one monitoring well located on the Reliance property, but at a concentration below the screening criteria. This suggests that the source of benzene in groundwater is primarily within the Seaman Shelton site. Benzene was not detected in groundwater samples from the lower portion of the unconfined aquifer.

The highest concentrations of 1,2,4-trimethylbenzene was detected in monitoring well PW-1, located within the Seaman Shelton site. Concentrations of 1,2,4-trimethylbenzene above screening criteria were also found in samples collected from monitoring wells located at Reliance, KPT, and immediately south of Yale Oil. 1,2,4-trimethylbenzene was not detected in groundwater samples from the lower portion of the unconfined aquifer.

Four petroleum hydrocarbon groups (C5-C8 aliphatics, C11-C22 aromatics, C9-C10 aliphatics, and C9-C12 aliphatics) were detected in groundwater samples at maximum concentrations that exceeded the screening criteria. Total extractable hydrocarbons (TEH) were detected in 15 of 28 samples and concentrations range from 220 µg/L (GWRM-2) to 3,500 µg/L (PW-1). No petroleum hydrocarbons were detected in the upgradient (background) monitoring well.

Elevated concentrations of C9-C10 aromatic hydrocarbons are located throughout the KRY Site, with the highest concentrations found in groundwater samples collected within the Seaman Shelton site. It appears that separate source areas are associated with the distribution of C9-C10 aromatic hydrocarbons in the upper portion of the unconfined aquifer. One source area is associated with the Seaman Shelton site which appears distinctly separate from other sources associated with KPT, Reliance, and Yale Oil facilities. C9-C10 aromatic hydrocarbons were not detected in groundwater samples from the lower portion of the unconfined aquifer.

Three metals (arsenic, iron, and manganese) were detected in groundwater samples at maximum

concentrations that exceeded the screening criteria. Arsenic, iron, manganese, and zinc were detected in groundwater samples from upgradient (background) well KRY101A. The background concentration of arsenic was 7U µg/L; meaning non-detect; iron was 230 µg/L; manganese was 778 µg/L; and zinc was 10U µg/L; meaning non-detect.

Groundwater upgradient, and in the vicinity, of the existing ozonation system on the KPT facility was analyzed for indicator analytes and breakdown products of PCP in an effort to evaluate the effectiveness of the ozonation system in reducing the concentrations of PCP in groundwater. These samples were also collected to evaluate whether the existing ozonation system may currently be generating toxic byproducts. Chloride ions and PCP concentrations were used as indicator analytes as well as potentially toxic byproducts of the oxidation of PCP including aldehydes (specifically, formaldehyde), ketones (specifically, acetone), and bromate.

Acetone, bromate, and formaldehyde were not detected in the groundwater samples and it therefore does not appear that the ozonation system is creating potentially toxic byproducts resulting from degradation of PCP. The presence of chloride suggests the breakdown of PCP. However, historical groundwater data demonstrate that chloride levels typically range between 1 and 8 mg/L across the KRY Site. The ozonation system does not appear to be increasing chloride concentrations downgradient of the system.

## **Surface Soil**

Surface soil samples were collected throughout the KRY Site during the RI at the KPT, Reliance, and Yale Oil facilities, adjacent commercial properties, and at adjacent residential areas. No chemicals other than dioxins and furans were detected at concentrations above screening criteria in surface soil samples collected from adjacent residential or background areas.

Eight SVOCs (PCP, chrysene, benzo[b]fluoranthene, indeno[1,2,3-cd]pyrene, benzo[a]anthracene, benzo[a]pyrene, dibenzo[a,h]anthracene, and naphthalene) are considered COPCs since they were detected at concentrations above the screening criteria.

Pentachlorophenol was detected in 261 surface soil samples with concentrations ranging from 0.0016 milligrams per kilogram (mg/kg) to 6,900 mg/kg. The highest concentrations of PCP in surface soil are located near the center of the KPT facility, within and east of the former excavation area. A small area of elevated PCP concentrations in surface soil is located within the Reliance Refinery, south of the railroad tracks. No PCP was detected in background surface soil samples.

The highest concentrations of benzo(a)pyrene in surface soil are located within the Reliance facility south of the railroad tracks. In addition, elevated concentrations of benzo(a)pyrene were detected at the Yale Oil facility.

Dioxins and furans (2,3,7,8-TCDD TEQ) had maximum detected concentrations that exceed screening levels. Dioxins and furans were detected in 117 surface soil samples with calculated 2,3,7,8-TCDD TEQ concentrations ranging from 0.099 nanograms per kilogram (ng/kg) to 171,510 ng/kg. The highest concentrations of 2,3,7,8-TCDD TEQ in surface soil are located within the KPT facility. Elevated concentrations of 2,3,7,8-TCDD TEQ in surface soil above background (4.8 ng/kg) but below the EPA Region 9 industrial PRG (15.9 ng/kg) were found in five samples from residential areas located east, south, and west of the KRY Site.

Two VOCs (benzene and methylene chloride) are considered COPCs since they were detected in surface soil samples at concentrations above the screening criteria. Benzene concentrations ranged from 0.008 mg/kg to 0.056 mg/kg. Methylene chloride concentrations ranged from 0.006 mg/kg to 7.14 mg/kg. No VOCs were detected in background surface soil samples (KRY560, KRY561, and KRY562). No tetraethyl-lead was detected in surface soil samples.

Six petroleum hydrocarbon groups (TEH, total petroleum hydrocarbons, C19-C36 aliphatics, C11-C22 aromatics, C9-C18 aliphatics, and C9-C12 aliphatics) are considered COPCs since they were detected at concentrations that exceeded screening criteria. TEH were detected in 140 of 155 samples. TEH and C11-C22 aromatic hydrocarbons were detected in background surface soil samples. C11-C22 aromatic hydrocarbon contamination is likely associated with diesel or other carrier oils used in wood treating operations at the KPT facility and petroleum feed stocks and products at the Reliance and Yale Oil facilities. The highest concentrations of C11-C22 aromatic hydrocarbons in surface soil are located within the Reliance facility in an area along the eastern border of the facility and a small area just north of the railroad tracks.

Eight metals (aluminum, arsenic, chromium, iron, lead, manganese, thallium, and vanadium) are considered COPCs since they were detected at concentrations that exceeded the screening criteria. Lead was detected in 119 surface soil samples with concentrations ranging from 7 mg/kg to 44,300 mg/kg. Lead at the KRY Site is likely associated with petroleum refining and products at the Reliance facility, although no evidence of a lead additive facility has been found. The highest concentrations of lead in surface soil are located near the southern boundary of the Reliance facility.

No characteristic hazardous wastes were identified through toxicity characteristic leaching procedure (TCLP) sampling of surface soil. Synthetic precipitation leaching procedure (SPLP) sampling of surface soil indicated that soil with PCP concentrations of 3 mg/kg produced leachate with no detectable PCP concentrations.

### **Subsurface Soil**

Subsurface soil sampling was conducted throughout the KRY Site during the RI at the KPT, Reliance and Yale Oil facilities, adjacent commercial properties, and adjacent residential areas. Twenty-two chemicals were detected in subsurface soil samples at concentrations above screening criteria.

Eleven SVOCs (PCP, carbazole [an aromatic hydrocarbon found in crude oil], benzo[b]fluoranthene, benzo[k]fluoranthene, fluorene, benzo[a]anthracene, benzo[a]pyrene, naphthalene, pyrene, dibenzofuran, and acenaphthene) are considered COPCs since they were detected at concentrations that exceeded screening criteria. Pentachlorophenol was detected in 128 subsurface soil samples, with concentrations ranging from 0.0014 mg/kg to 2,200 mg/kg. The highest concentrations of PCP in subsurface soil are located within and downgradient of the KPT facility. Benzo(a)pyrene was detected in 28 subsurface soil samples, with concentrations ranging from 0.0123 mg/kg to 8 mg/kg. The highest concentrations of benzo(a)pyrene in surface soil are located within the Reliance facility.

Dioxins and furans were detected in 63 subsurface soil samples with calculated 2,3,7,8-TCDD TEQ concentrations ranging from 0.249 ng/kg to 20,652 ng/kg. The highest concentrations of 2,3,7,8-TCDD TEQ in subsurface soil are located within the KPT facility.

Five VOCs (ethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, toluene, and xylenes) are considered COPCs since they were detected at concentrations that exceeded screening criteria. No tetraethyl-lead was detected in subsurface soil samples.

Eight petroleum hydrocarbon groups (total petroleum hydrocarbons, TEH, C19-C36 aliphatics, C11-C22 aromatics, C9-C18 aliphatics, C9-C10 aromatics, C5-C8 aliphatics, and C9-C12 aliphatics) are considered COPCs since they were detected at concentrations that exceeded screening criteria. C9-C18 aliphatic hydrocarbons were detected in 138 subsurface soil samples, with concentrations ranging from 3 mg/kg to 163,000 mg/kg. The highest concentrations of C9-C18 aliphatic hydrocarbons in subsurface soil are located within the Reliance facility.

Eight metals (aluminum, arsenic, chromium, iron, lead, manganese, selenium, and vanadium) are

considered COPCs since they were detected at concentrations that exceeded the screening criteria. Lead was detected in 137 subsurface soil samples, with concentrations ranging from 5 mg/kg to 4,190 mg/kg. The highest concentrations of lead in subsurface soil are located within the Reliance facility.

SPLP sampling of subsurface soil indicated that soil with PCP concentrations of 318 mg/kg produced a leachate with PCP concentrations of 3.3 mg/L. Other SPLP results suggest that soil with PCP concentrations of up to 7 mg/kg produced a leachate with no detectable PCP concentrations.

### **Surface Water and Sediment**

Surface water and sediment samples were collected from the Stillwater River adjacent to the KPT and Reliance facilities during the RI. Detected analytes include metals, SVOCs, and petroleum compounds. Once chemical, 2,3,7,8-TCDD TEQ, is considered a COPC in surface water since it was detected at concentrations above screening criteria and above background levels. However, no chemicals were detected in sediment samples at concentrations above the freshwater sediment criteria.

### **Contaminant Fate and Transport**

The RI considered five COPCs or groups of COPCs as the most significant from a risk and remediation standpoint. The five groups include: PCP, dioxins and furans, PAHs, petroleum hydrocarbons, and lead. General fate and transport processes that may attenuate concentrations of contaminants include dispersion, dilution, sorption, volatilization, abiotic degradation, and biodegradation.

The RI describes the general physical, chemical, and toxicological properties of the site COPCs as well as a discussion of the fate and transport processes of the COPCs, particularly with respect to destructive and nondestructive attenuation processes. The RI also describes a preliminary Conceptual Site Model (CSM).

The CSM presents known and potential contaminant sources and contaminant release and migration mechanisms. The CSM also presents potential contaminant exposure pathways and routes, and human and ecological receptors that are expected to be evaluated as part of the risk analysis. Use of the CSM is an ongoing, and iterative approach allowing the CSM to evolve and mature as site work progresses and data gaps are filled. A more detailed conceptual site exposure model will be developed for use in the risk analysis to further refine exposure media, exposure routes, and receptor pathways.

## **RI Conclusions and Recommendations**

The RI identified three primary sources of groundwater contamination within the site: the KPT facility source area, the Reliance facility source area, and the Yale source area. A fourth, off-site source area was identified at the Seaman Shelton site (near Northern Energy Propane). Primary sources of COPCs appear to be at the KPT and Reliance facilities with minor source concentrations at the Yale Oil facility. No other source areas have been identified based on the results of both groundwater and soil samples. Soil contamination south of Office Max at the Yale Oil facility may be from a source other than the Yale Oil facility.

Portions of the groundwater within and downgradient of these sources contain chemicals at concentrations greater than both federal and state regulatory standards. Soil at the site contains chemicals at concentrations greater than both federal and state screening criteria. With the exception of 2,3,7,8-TCDD TEQ in surface water, chemicals and metals in surface water and sediment of the Stillwater River are at concentrations below federal and state screening criteria.

Surface and subsurface soil with COPCs at concentrations above site-specific screening criteria are considered potential sources for groundwater contamination. No surface or subsurface samples from locations outside the identified source areas contained COPCs at concentrations above screening criteria with two exceptions. One subsurface sample immediately north of the northeast corner of the KPT facility contained petroleum hydrocarbons with concentrations above screening criteria and surface soil samples in some residential areas contained dioxin and furans at levels slightly above the residential PRG.

The highest concentrations of PCP, dioxin and furan, and SVOCs in groundwater at the KRY Site have been reported in the portions of the plume within and downgradient of the KPT facility source area. In addition, lower level concentrations of PCP, dioxin and furan, and SVOCs in groundwater have been reported within the Reliance facility source area and downgradient of both the KPT facility and Reliance facility source areas. The extent of this contamination has generally been delineated by samples that did not contain COPCs at concentrations above laboratory detection limits. However, the eastern edge of groundwater contamination is not well delineated at intermediate and deep portions of the unconfined aquifer both upgradient and downgradient of well KRY129B.

The highest concentrations of petroleum contamination (EPH and VPH) at the KRY Site have been reported in portions of the plume within the KPT and Reliance facilities with lower concentrations within

and around the Yale Oil facility. Petroleum contamination at the Seaman Shelton site is considered separate from, and unrelated to contamination at the KPT, Reliance, and Yale Oil facilities.

Several data gaps have been identified after a review of all data collected during the RI. Additional work is recommended at the KRY Site and includes:

- Additional studies are recommended to optimize the enhancement and maximize denitrifying bacteria activity and the rates of hydrocarbon biodegradation.
- Quarterly monitoring of select residential wells is currently being conducted since pentachlorophenol contamination was identified in some of these wells during the RI.
- Monthly groundwater and surface water levels are being recorded to better define potentiometric surfaces and groundwater and surface water interaction throughout the year.
- The reason for the large vertical gradients between some the well pairs at KRY125 and KRY129 is not known. Well completion in the varying geology may be responsible for the observed gradients. Ongoing monthly groundwater level data should be evaluated and may provide additional insight.
- Transportation and off-site disposal of contaminated materials from the KRY Site should require characteristic hazardous waste determination for ignitability, corrosivity, and reactivity.
- Dioxin and furan concentrations in surface water were found to be elevated. However, the number of surface water dioxin and furan data is small (three samples) and additional sampling is recommended to determine if further action is necessary.
- Three additional monitoring wells are recommended to define the horizontal extent of petroleum contamination in the Seaman Shelton area. Wells should be installed east, south, and west of monitoring wells NTL-MW-3 and NTL-MW-4.
- Additional sampling during remedial design is proposed at sampling locations within the southern half of the Reliance facility where the vertical extent of contamination is not fully defined. Subsurface sampling has adequately characterized elevated petroleum hydrocarbon contamination in this area to depths corresponding with the groundwater level smear zone (approximately 15 to 20 feet bgs) but little sampling occurred below these depths.
- One additional monitoring well completed in the lower portion of the unconfined aquifer is recommended to be installed downgradient of monitoring well KRY129B to define the limits of groundwater contamination in this area.
- One additional monitoring well completed in the lower portion of the unconfined aquifer is recommended to be installed north of the Reliance facility. It may be possible that there is PCP in the deeper portion of the aquifer underlying the residential areas north of the Reliance facility and with limited deep wells in the vicinity it is impossible to determine if there is a preferential flow pathway.

- Two additional monitoring wells completed in the intermediate portion of the unconfined aquifer (midway between the upper and lower portions of the unconfined aquifer) are recommended to be installed to define the concentrations of groundwater contamination at this depth in the aquifer. One of these wells is recommended to be located mid-way between monitoring wells KRY121B and KRY129B. One of these wells is recommended to be located mid-way between KRY121B and KRY111B. Sampling from these wells would more fully define the vertical and horizontal extent of PCP contamination in this area necessary to evaluate remedial options for this portion of the groundwater plume.

## **1.0 INTRODUCTION**

This remedial investigation (RI) report presents the geologic, hydrogeologic, and chemical data gathered during the field efforts for the investigation conducted at the Kalispell Pole and Timber (KPT) facility, Reliance Refinery Company (Reliance) facility, and Yale Oil Corporation (Yale Oil) facility (collectively known as the KRY Site) from April 2006 through August 2006. In addition, this report considers historical data generated from previous investigations at the site. Tetra Tech EM Inc. (TtEMI) performed this work under Task Order No. 37 from the Montana Department of Environmental Quality (DEQ), Remediation Division, under DEQ Contract No. 402014. The task order requests that TtEMI prepare an RI report for the KRY Site. This RI report includes the elements required as delineated by Task No. 5 in Task Order No. 37.

The KRY Site is located on the northeastern edge but outside of the city limits of the City of Kalispell in the community of Evergreen in Flathead County, Montana. The three facilities are close to each other and nearby residential areas and occupy a total area of approximately 55 acres south of the Stillwater River. Groundwater contamination from various sources is commingled in the upper unconfined aquifer. Contaminants in soil and groundwater include semi-volatile organic compounds (SVOCs) including pentachlorophenol (PCP) and polycyclic aromatic hydrocarbons (PAHs), dioxins and furans, volatile organic compounds (VOCs), petroleum hydrocarbons, and metals, most notably lead. The investigation and data collection were conducted as described in the remedial investigation work plan (RIWP) and sampling and analysis plan (SAP) (TtEMI 2006).

### **1.1 REPORT ORGANIZATION**

This RI is organized in six sections, followed by literature references, tables and figures, which are followed by appendices. The contents of Sections 1.0 through 6.0 are briefly described below.

Section 1.0, Introduction - describes the report organization, the report purpose and objectives, and the site and site history, and summarizes previous and ongoing investigations.

Section 2.0, Investigation Procedures and Field Methods - describes the investigative procedures, field methods and activities, quality assurance (QA) and quality control (QC) methods and samples, management of investigation-derived waste, opportunistic sampling, and deviations from the RIWP.

Section 3.0, Physical Characteristics and Environmental Setting - describes the climate, ecology, soils, geology, surface water hydrology, and hydrogeology of the KRY Site, and presents field parameters.

Section 4.0, Nature and Extent of Contamination - summarizes the current understanding of the nature and extent of contamination based on field observations, field parameters, and validated analytical data from soil, surface water, sediment, and groundwater samples. In addition, this section identifies contaminants of potential concern, sources of contamination, and contaminant background concentrations.

Section 5.0, Contaminant Fate and Transport - summarizes the properties of contaminants of potential concern and fate and transport processes, and presents an updated conceptual site model.

Section 6.0, Conclusions and Recommendations - presents conclusions and recommendations for the RI report and describes the feasibility study (FS) process.

The appendices follow the text and include:

Appendix A – Western Research Institute Data

Appendix B – Field Logs

Appendix C – Photographic Log

Appendix D – Monitoring Well and Borehole Logs

Appendix E – Monitoring Well Development Forms and Groundwater Sampling Data Sheets

Appendix F – Global Positioning System (GPS) and Survey Location Information

Appendix G – Laboratory Analytical Results

Appendix H – Data Quality Assessment and Data Validation Reports

Appendix I – Aquifer Test Graphical Solutions

## **1.2 PURPOSE AND OBJECTIVES**

The purpose of the RI is to collect data necessary to adequately characterize the site for developing and evaluating effective remedial alternatives that address human health and environmental risks at the site. Activities developed and conducted under the KRY RI included project scoping, and collecting, evaluating, and interpreting data. Activities for the KRY RI were performed in accordance with the *Final Remedial Investigation Work Plan, Sampling and Analysis Plan, and Health and Safety Plan, Kalispell*

*Pole And Timber, Reliance Refinery, and Yale Oil Facilities* (TtEMI 2006). The primary objectives of the RI for the KRY Site include the following:

- Adequately characterize the nature and extent of releases or threatened releases of hazardous or deleterious substances,
- Allow the effective development and evaluation of alternative remedies to be included in the FS, and
- Allow an assessment of health and ecological risks and development of cleanup levels.

The primary objective of this document is to describe the results of the RI at the KRY Site and present the results along with historical data. This RI report has been prepared in accordance with the Montana Comprehensive Environmental Cleanup and Responsibility Act (CECRA), as well as DEQ and U.S. Environmental Protection Agency (EPA) guidance, as appropriate. In addition, this RI report summarizes historical site activities, remedial actions, and other information pertinent to characterizing the KRY Site.

### **1.3 SITE DESCRIPTION**

The KRY Site is located on the northeastern edge but outside the city limits of the City of Kalispell in the community of Evergreen in Flathead County, Montana (Figure 1-1). The site is located at 48°12' North latitude, 114°17' West longitude, and is in (1) the Northeast ¼ of the Northwest ¼ of Section 8, (2) the Northwest ¼ of the Northeast ¼ of Section 8, and (3) the Southeast ¼ of the Southwest ¼ of Section 5; all within Township 28 North, Range 21 West of the Montana Principal Meridian. The boundaries of the KRY Site generally extend from the Stillwater River on the north and west, Highway 2 and the BNSF Railway Company (BNSF) railroad line on the east, Montclair Drive on the south, and Whitefish Stage Road on the west (Figure 1-2). The actual site boundaries are based on the extent of groundwater contamination identified through the RI and can be seen on Figure 4-1, which is a depiction of PCP contamination across the facilities. The fenced area northeast of Reliance and adjacent to (east of) the railroad tracks is also part of the Reliance facility.

### **1.4 SITE HISTORY**

This section presents an overview of the operational and property ownership history for the KPT, Reliance, and Yale Oil facilities. Current ownership of the individual parcels and historical property ownership are presented in Section 2.3 of the data summary report (DSR) (TtEMI 2005).

#### **1.4.1 Kalispell Pole and Timber Facility**

KPT is a former wood treating facility that operated from approximately 1945 to 1990. The facility encompasses approximately 35 acres. Spills or leaks of wood treating oil that contained PCP from the treatment vats, aboveground storage tanks, and treated wood contaminated on-site soils and groundwater with PCP, dioxins and furans, PAHs, and diesel-range petroleum hydrocarbons.

KPT was incorporated on July 8, 1944. On October 8, 1945, KPT leased from the Great Northern Railroad Company a 300 feet by 200 feet space in or near the area where the pole plant was ultimately constructed. BNSF's predecessor companies (Burlington Northern Railroad Company; Burlington Northern, Inc.; and Great Northern Railroad Company) leased portions of its property to KPT beginning on June 1, 1947, and possibly as early as October 8, 1945, for the location and operation of a treating plant and storage yard. KPT owned and operated the pole plant for its entire operating life, from approximately 1945 through approximately May 1990. The KPT board of directors approved the dissolution of the corporation as of December 31, 1990. KPT was involuntarily dissolved by the state on December 6, 1991. KPT abandoned the leased property in about May 1990. However, KPT's lease for the property has never been canceled or transferred. When the pole treating operations ended, KPT dismantled and removed all treating vats and aboveground storage tanks and piping (Historical Research Associates, Inc. [HRA] 1995).

HRA interviewed former KPT employees, who provided details on the wood treating process used at the plant (HRA 1995). First, blocks of PCP were melted with hot oil (5 percent PCP by weight) in a vat using a steam process to create a "treating oil" that reached temperatures as high as 210 to 230 degrees Fahrenheit (°F). Then, the hot treating oil was added to a large vat that contained the wood to be treated for an average treatment time of about 10 hours per load. Sample drillings into the treated wood verified whether the preservative had sufficiently penetrated the wood. The treated wood was usually loaded and shipped shortly after it was treated. It was noted that "foam overs" of the wood treating solution could occur when precipitation reacted with heated oil in the treatment vats.

KPT treated poles at the pole plant using a butt vat and a full-length vat. KPT added the full-length vat to its operation in 1957 (HRA 1995). The dimensions of the butt vat were 10 feet wide by 10 feet deep by 18 feet long. The capacity of the butt vat was 13,465 gallons. In the butt vat treatment process, poles were placed vertically (upright) into the vat. The dimensions of the full-length vat were 10 feet wide by 10 feet deep by 70 feet long. The capacity of the full-length vat was 52,367 gallons. In the full-length

treatment process, poles were placed horizontally into the vat. The full-length vat was also used for mixing PCP and oil (BNSF v. KPTC 2000).

KPT records show that, between September 1959 and June 1998, KPT purchased at least 2,298,081 pounds of PCP. Records also show that, between September 1959 and October 1989, KPT purchased at least 5,310,096 gallons of wood treating oil (BNSF v. KPTC 2000).

BNSF and its predecessors owned and currently own a portion of the property where KPT operated and where the wood treatment facility was located. BNSF shipped freight via railcar to and from KPT. Freight shipped by BNSF to KPT included untreated poles, PCP, and oil. Freight shipped by BNSF from KPT included treated poles. BNSF freight records for 1968 through 1970 show that 184 railcars of freight were delivered to KPT and that 296 railcars of freight were forwarded from KPT. Records for 1973 through 1976 show that approximately 80 railcars of freight were forwarded from KPT. BNSF shipped no freight via railcar, or otherwise, to or from KPT after about 1980 (BNSF v. KPTC 2000). Freight was also shipped to and from KPT by truck.

BNSF and its predecessor companies have and are currently leasing property to lumber-processing facilities. Klingler Lumber Company appears to be operating either on top of or directly adjacent to the former pole treating area. Montana Mokko had operated adjacent to (west of) the former pole treating area, but these operations appeared to have ceased by the time RI field activities were conducted. It was noted during RI field activities that a stone processing company (Glacier Stone Company) was operating within portions of the former Montana Mokko lumber-processing area.

A number of regulatory events have taken place for the former KPT wood treatment facility (DEQ 2005), including:

- On August 16, 1980, KPT submitted the first EPA Notification of Hazardous Waste Activity Form.
- On August 10, 1983, the Montana Department of Health and Environmental Sciences (MDHES) Hazardous Waste Program conducted an inspection of the KPT operation. No violations were noted in the Field Investigation Report; KPT operation retained listing as a small quantity generator.
- On October 1, 1986, MDHES Hazardous Waste Program conducted an inspection of the KPT operation. No violations were noted in the Field Investigation Report.
- On September 16, 1988, MDHES Hazardous Waste Program conducted an inspection of the KPT operation. The Field Investigation Report is not present in the project file.

- In 1991, the Hazardous Waste Program Resource Conservation and Recovery Act (RCRA) project file was closed because KPT had ceased operations and dismantled the wood treatment facility.
- In 1994, Burlington Northern Railroad submitted a Regulated Waste Activity Form for investigation derived waste (purge water) and classified as a Class II large quantity generator. This classification was later changed to Class I large quantity generator, which is still in effect. BNSF also began submitting annual generator reports.

A number of investigations and interim actions have been conducted at the KPT facility (DEQ 2005), including:

- In August 1980, the KPT facility was listed on the Comprehensive Environmental Response, Compensation, and Liability Information System (CERCLIS).
- A 1985 Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) preliminary assessment by MDHES noted the potential for PCP contamination at the facility.
- A 1988 CERCLA Phase I site investigation by MDHES consultants found high levels of PCP and dioxins and furans in on-site soils and groundwater and elevated levels of some PAHs and metals, notably lead.
- A 1989 CERCLA Phase II site investigation by MDHES consultants concluded that groundwater contamination was migrating off site to the east/southeast.
- A 1991 CERCLA Phase III site investigation by MDHES consultants found no contamination in the Evergreen municipal wells or in most nearby residential wells, but found PCP in a downgradient residential well and very low levels of petroleum hydrocarbons in another downgradient irrigation well. MDHES subsequently conducted semi-annual domestic well sampling until 1998.
- In 1991, Burlington Northern Railroad, at Montana Mokko's expense, expanded the spur line to access Montana Mokko's operation. The spur line was constructed very close to, and possibly on top of, some of the worst known areas of soil contamination on the facility.
- In 1991, consultants to the EPA conducted a detailed hydrogeologic investigation to better define groundwater movement and contamination in soil and groundwater. This investigation was the result of an MDHES request for EPA emergency removal action in 1990.
- In September 1993, Montana Mokko and Klingler Lumber Company agreed to stipulation with regard to National Ambient Air Quality Standard for Particulate Matter and Montana Ambient Air Quality Standard for fine particulate matter (PM<sub>10</sub>) after the Kalispell area was designated as a non-attainment area for particulate matter. The stipulations signed by Montana Mokko and Klingler Lumber Company (as well as MDHES) were related to the overall plan to come into compliance with the standards.

Both parties agreed to the following requirements (among others): not cause or authorize emissions to be discharged into the outdoor atmosphere from equipment on the property, from access roads, parking lots, log decks, or the general plant property (with some specific opacity levels); to treat all unpaved portions of the haul roads, access roads, parking lots, log decks, and the general plant area with water or chemical dust suppressant as necessary to maintain

compliance; to operate and maintain all emission control equipment; and to submit an annual emission inventory to MDHES Air Quality Bureau for the listed emission points.

- In 1992, consultants for a potential buyer of a property south of Highway 2 conducted a Phase I and II environmental site assessment to evaluate whether the property was affected by contamination from the three nearby CECRA facilities. Petroleum hydrocarbons and low levels of several PAHs were found in soil and groundwater on the property, but the source of contamination had not been identified. Several potential sources were noted to exist in the area.
- In 1994, MDHES consultants prepared a draft Hazard Ranking System (HRS) package for the KPT and Reliance facilities. An evaluation of the facilities indicated that both facilities (in combination) were candidates for the National Priorities List (NPL). The facilities were never actually proposed for listing, but the HRS package was prepared.
- In 1994, Burlington Northern Railroad consultants completed an investigation at the facility to confirm the results of previous investigations, replace damaged monitoring wells, and collect additional data. Free product or a petroleum sheen was detected in most of the monitoring wells during most sampling events. The free product was generally less than one foot thick. A plume of dissolved PCP and dioxins and furans was also found.
- In 1995, DEQ noticed BNSF, KPT, and Montana Mokko as potentially liable persons (PLP) under CECRA for the KPT facility.
- In 1995, BNSF canceled the lease of the potato warehouse and stated plans to remove the building. The warehouse was torn down between mid-1995 and 1998. The Site Investigation Report for KPT, prepared by Remediation Technologies, Inc. (RETEC) in July 1995, presents figures depicting the location of the potato warehouse. The Supplemental Remedial Investigation Report for KPT, prepared by RETEC in February 1998, presents figures depicting the location of the former potato warehouse.
- In the mid-1990s, a small building located on the state-owned portion of the KPT facility was removed. This building was located in the eastern portion of the property adjacent to Flathead Drive. The building is visible on the 1995 aerial photograph of the area. The building is not present on the 2004 aerial photograph. It appears the building was part of the oil refinery since the building is depicted and labeled on the 1950 and 1963 Sanborn Fire Insurance Maps for the Unity Petroleum Corporation refinery.
- In 1996, BNSF consultants began additional investigations to delineate the contaminant plumes of PCP and nonaqueous phase liquids (NAPL). The BNSF consultants installed five new monitoring wells and began a pilot air-sparging program. Sampling of local domestic wells by DEQ found PCP and petroleum contamination for the first time since the 1991 sampling event.
- In 1997, BNSF connected one local residence to the city water system.
- In 1997 and 1998, BNSF consultants conducted a supplemental RI. The purpose of this investigation was to fill data gaps identified during the investigation in 1994 and 1995; delineate the downgradient extent of the plume of dissolved PCP; characterize the western edge of light nonaqueous phase liquid (LNAPL) contamination; calculate the direction of groundwater flow in the northern portion of the facility; calculate groundwater velocity during low-water periods, and assess the extent of surface PCP contamination in soil.
- In April 1999, a one-time soil excavation was conducted to remove PCP hot spots in shallow soils and transport them off site for disposal in a Subtitle C facility. This action occurred before the Phase IV Land Disposal Restrictions were promulgated that prohibited F032-contaminated soils

and debris from land disposal. F032 is a RCRA hazardous waste designation for wastes from some wood preserving processes (40 Code of Federal Regulations [CFR] Section 261.31). BNSF consultants excavated approximately 470 cubic yards of contaminated soils from the former treatment area located at the facility. The contaminated soils were transported to and disposed of at Chemical Waste Management of the Northwest, Waste Management Industrial Services' Subtitle C landfill located in Arlington, Oregon.

- In December 1998, proper and expeditious (P&E) letters were sent, pursuant to Montana Code Annotated § 75-10-711(3), to the PLPs who had received notice letters asking them to undertake the work necessary at the KPT facility. At this time, the noticed parties for the KPT facility included BNSF, KPT, and Montana Mokko.
- In 2001, BNSF resumed sampling of groundwater monitoring wells associated with the facility to further define the magnitude and extent of contamination associated with the KPT facility. Samples were analyzed for PCP, extractable petroleum hydrocarbons, semivolatile organic compounds (SVOC), and dioxins and furans. BNSF consultants have conducted semi-annual groundwater sampling since 2001.
- In November 2001, DEQ noticed Klingler Lumber Company, Swank Enterprises, and the Montana Department of Natural Resources and Conservation (DNRC) as PLPs for the KPT facility.
- In 2004, BNSF upgraded the ozonation system (originally installed in 1999 as a pilot-scale system) to be a full-scale system without DEQ approval or oversight. DEQ reviewed and commented on the "as-built" report in April 2005. BNSF again modified the ozonation system in September 2006 without DEQ approval or oversight.
- In July 2004, DEQ filed a lawsuit naming the noticed PLPs as defendants. In the lawsuit, DEQ requests reimbursement of its oversight costs and a court order requiring the defendants to conduct remedial actions. DEQ's CECRA program is acting as the lead agency for the facility and has ranked it a high priority.
- In November 2005, BNSF consultants conducted monitoring well installation, soil borings, and surface soil sampling at the KPT and Reliance facilities.
- In December 2005, TtEMI prepared a DSR on behalf of DEQ.
- In March 2006, TtEMI prepared the RIWP (TtEMI 2006) on behalf of DEQ.
- In April 2006 through August 2006, TtEMI conducted RI field work to collect data for the RI report.

#### **1.4.2 Reliance Refinery Company Facility**

Reliance is a former oil refinery that operated from 1924 to the 1960s. The facility encompasses approximately 7 acres. On-site disposal of sludge, leaks of sludge and oil from aboveground storage tanks, and off-loading of crude oil contaminated soil with petroleum hydrocarbons and some metals, notably lead. Groundwater beneath the Reliance facility is contaminated with petroleum hydrocarbons, PCP, dioxins and furans, and PAHs.

The Reliance Refining Company was incorporated on November 14, 1923, after oil was discovered in the Kevin-Sunburst fields in north-central Montana in October 1923. The Reliance Refining Company owned and operated the refinery from 1924 to 1930. A fractionating oil refinery was constructed in about 9 months, and refining operations started by November 1924. By November 1925, the refinery was producing 20,000 gallons of gasoline daily (HRA 1995). The refinery also produced kerosene, jet fuel, distillates, gas oil (diesel engine oil), transmission oil, floor oil, and other petroleum byproducts. The crude oil and petroleum products were stored in aboveground storage tanks and earthen dikes/barrow pits. In 1929, a cracking plant was installed at the facility (EPA Field Investigation Team [FIT] 1986, EPA 1992).

The refinery property was sold for back taxes to the State of Montana at a public auction held on November 21, 1930; the final deed was issued on December 26, 1935. Boris Aronow, doing business as Unity Petroleum Corporation, leased the property from the state on December 5, 1930. The lease expired on November 26, 1935. The Reliance Refining Company was sold to Boris Aronow in February 1932. The Unity Petroleum Corporation was incorporated in March 1933. The Unity Petroleum Corporation leased and operated the property from 1935 until 1969.

There are conflicting reports on the length of time the refinery operated at the facility. Unity Petroleum Corporation was listed in the Kalispell city directories between 1928 and 1944. However, there were no listings in the city directories between 1945 and 1956. The last two listings for Unity Petroleum were in 1957 and 1959. These two listings identified Tony Schumacher as a bookkeeper for Unity Petroleum (HRA 1995). Mr. Aronow reported that bulk storage operations continued at the site into the 1960s (State Board of Land Commissioners 1962). There are listings in the city directories from 1962 through 1969 for Schumacher's Evergreen Fuel Company. The 1963 Sanborn map contains a note that the oil refinery was no longer in operation and that only one person was working at the facility. The refinery was dismantled in 1970 (EPA FIT 1986, EPA 1992). The state involuntarily dissolved the Unity Petroleum Corporation in 1982 for failure to provide annual reports and fees (HRA 1995).

The State of Montana leased the property to KPT on August 13, 1969; the lease was terminated on January 28, 1994 (Pioneer Technical Services [PTS] 2000). KPT leased the property for storage of poles. In 1973, KPT requested permission from MDHES to cover an aboveground storage tank with wood chips. The tank, which contained 16 inches of tar, had been cut off near the floor, leaving the bottom and lower sidewalls of the tank in place. MDHES granted KPT permission (DEQ 1973), and the tank bottom was covered with wood chips (EPA FIT 1986).

The southern portion of the facility was used to store poles. KPT personnel have claimed that butt dipping occurred at the Reliance Facility as a one-man operation. KPT personnel said that this technique was used sometime between 1968 and 1973 and lasted only 3 to 4 years. The treatment included cold soaking poles in drums of treatment fluid (DNRC 1988). In 1988, the EPA constructed a security fence around the southern portion of the facility. The fenced area is located on the state-owned portion of the facility. The EPA also fenced a small area northeast of the facility and adjacent to (east of) the railroad tracks. The fences were constructed based on reports of children playing in sludge pits at those locations. KPT conducted operations on the property until May 1990. The KPT board of directors approved the dissolution of the corporation as of December 31, 1990. KPT was involuntarily dissolved by the state on December 6, 1991.

A number of investigations and interim actions have been conducted at the Reliance facility (DEQ 2005), including:

- In January 1985, the Reliance facility was listed on CERCLIS.
- A 1985 CERCLA preliminary assessment by MDHES noted the potential for contamination at the facility.
- A 1986 CERCLA initial investigation by EPA contractors found dioxins in on-site soils.
- In 1988, the EPA Emergency Removal Branch constructed a security fence around a portion of the facility and posted hazard warning signs based on reports that children were playing in the sludge pits.
- A 1988 CERCLA Phase I site investigation by MDHES consultants revealed high levels of total petroleum hydrocarbons (TPH), metals (primarily lead), and PAHs, and low levels of dioxins at the Reliance facility. PCP was found in one soil sample and in groundwater.
- A 1989 CERCLA Phase II site investigation by MDHES consultants concluded that groundwater contamination was migrating off site and to the east/southeast.
- A 1991 CERCLA Phase III site investigation by MDHES consultants found no contamination in the Evergreen municipal wells or in most nearby residential wells, but found PCP in a downgradient residential well and very low levels of petroleum hydrocarbons in another downgradient irrigation well. MDHES subsequently sampled domestic wells semi-annually until 1998.
- In 1992, consultants for a potential buyer of a property south of Highway 2 conducted a Phase I and II environmental assessment to evaluate whether the property was affected by contamination from the three nearby CECRA facilities. Petroleum hydrocarbons and low levels of several PAHs were found in soil and groundwater on the property, but the contaminant source had not been identified. Several potential sources were noted to exist in the area.
- In 1994, MDHES consultants removed barrels of contaminated purge water and drill cuttings, which had been stored inside the fence at the Reliance facility. The water and cuttings were from past investigations at the Reliance, KPT, and Yale Oil facilities.

- In 1994, MDHES consultants prepared a draft HRS package for the KPT and Reliance facilities. An evaluation of the facilities indicated that both facilities (in combination) were candidates for the NPL. The facilities were never actually proposed for listing, but the HRS package was prepared.
- In 1995, DEQ noticed BNSF, Klingler Lumber Company, and Swank Enterprises as PLPs under CECRA for the Reliance facility.
- In 1996 and 1997, DNRC applied for and received two grants for preparation and submittal of a Voluntary Cleanup Plan for removing, treating, and recycling approximately 20,000 cubic yards of petroleum-contaminated soils in an asphalt batch plant with the end product used for highway construction. These activities did not occur.
- In 1996, DEQ consultants completed a draft RI for a portion of the facility. A Final Draft FS Report was prepared in December 1997. The RI was finalized as a Phase I RI report in December 2000.
- In February 2000, DNRC submitted a report detailing the preliminary screening of remedial alternatives for the facility. The report represented potential interim actions to address contaminants in soils on the state-owned portion of the facility. DEQ was unable to approve the document because the interim actions proposed were not consistent with final cleanup.
- In October 2000, and pursuant to Montana Code Annotated § 75-10-711(3), P&E letters were sent to the noticed PLPs asking them to undertake the work necessary at the Reliance facility. At the time, the parties who received notice for the Reliance facility included BNSF, Klingler Lumber Company, and Swank Enterprises.
- In October 2000, BNSF requested that DNRC be noticed as a PLP for the Reliance facility. In 2001, DNRC requested that it be noticed as a PLP for the Reliance facility.
- In November 2001, notice letters were also sent to McElroy and Wilken, Inc., and to DNRC, identifying them as PLPs under CECRA for the Reliance facility. When the company received the notice letter, McElroy and Wilken, Inc. characterized its portion of the facility to further evaluate the presence of contamination. Activities included installation of two groundwater monitoring wells and collection of soil samples. Soil and groundwater samples were evaluated for PCP, TPH, and dioxins. McElroy and Wilken, Inc. was granted a subsurface migration exclusion as a result of the additional investigations.
- In 2002, DNRC conducted an interim investigation at the facility to address specific data gaps and to initiate groundwater remediation. Two free-phase recovery wells were installed, and recovery of free product began in July 2002. Additional soil samples were collected to further characterize contamination in soil across the facility. Routine groundwater monitoring was also initiated and was conducted in conjunction with monitoring for the adjacent KPT facility. DNRC submitted a Phase II RI/FS to DEQ in December 2002.
- In October 2002, Klingler Lumber Company was removed from the PLP list for the Reliance facility after it provided information indicating it had never owned property at Reliance.
- In July 2004, DEQ filed a lawsuit naming the PLPs who had received notice letters as defendants (except McElroy and Wilken and Klingler, who were previously removed from the PLP list). In the lawsuit, DEQ requested reimbursement of its oversight costs and a court order to require the defendants to conduct remedial actions. DEQ's CECRA program is acting as the lead agency for the facility and has ranked it a high priority.

- In November 2005, BNSF consultants conducted monitoring well installation, soil borings, and surface soil sampling at the KPT and Reliance facilities.
- In December 2005, TtEMI prepared a DSR on behalf of DEQ.
- In March 2006, TtEMI prepared the RIWP (TtEMI 2006) on behalf of DEQ.
- In April 2006 through August 2006, TtEMI conducted RI field work to collect data for the RI report.

### **1.4.3 Yale Oil Corporation Facility**

The Yale Oil Facility is a former petroleum bulk plant and product refinery that operated from 1938 to 1978. The facility encompasses approximately 2.3 acres. Leaks and possible spills from aboveground storage tanks contaminated on-site soils. Thermal desorption, using a permitted unit, was conducted on the soils to remove petroleum hydrocarbon contamination. However, groundwater beneath the facility is contaminated with PCP, dioxins and furans, and petroleum hydrocarbons.

Yale Oil Corporation developed the property for use as a refinery and bulk plant in the 1930s. The first evidence that Yale Oil had established a business in Kalispell appears in the 1936 city directory (HRA 1995). The facility refined crude oil from the Kevin-Sunburst oil fields in north-central Montana, which were developed in 1923. Crude oil was delivered to the facility by truck and rail. The refinery has been described as a small operation with a daily capacity of 500 barrels. Tractor fuel (similar to diesel) and fuel oil were the primary products of the refinery. Crude oil and petroleum products were stored in aboveground storage tanks.

Yale Oil Corporation owned and operated the facility until 1944, when the property was sold to Carter Oil Company. Refining operations at the facility ceased shortly after. Facility features present on the 1927 Sanborn map are labeled as “not used” on the 1950 Sanborn Map. As early as 1945, Carter Oil leased the property to the T.J. Landry Oil Company, Inc., a petroleum products distributorship. Mr. Landry ran the distributorship until he turned over management of the operation to his son-in-law, Bill Roberts. Mr. Roberts managed the distributorship until 1978 (Applied Earth Sciences, Inc. [AES] 1986).

On December 15, 1959, Carter Oil, along with Esso Standard Oil, merged with Humble Oil and Refining Company. Humble Oil merged with Exxon Corporation on December 26, 1972 (HRA 1995). In February 1978, the bulk plant operations at the facility were closed. The product inventory and all storage tanks, except the No. 5 fuel oil tank, were purchased by City Service Center and then moved to its property south of Kalispell.

In February 1980, Exxon Corporation granted the property to the Exxon Education Foundation. The property was sold to the National Development Corporation in December 1981. In 1982, the Pacific Iron and Steel Division of Pacific Hide and Fur dismantled the No. 5 fuel oil tank. The No. 5 fuel oil tank was cut off near ground level, leaving the tank bottom and lower sidewalls in place. Any product, sludge, or tank bottom that remained in the tank was left in place (AES 1986). In October 1983, property ownership reverted to the Exxon Education Foundation and subsequently to Exxon Corporation in November 1988. The current property owner is Kalispell Partners LLC, and a commercial business currently exists on the facility.

One regulatory event has taken place for the former Yale Oil facility (DEQ 2005):

- On February 24, 1993, a remediation contractor, GEM Division of Ryan Murphy, applied for and subsequently received an air quality permit to operate a thermal desorption unit at the facility to treat petroleum contaminated soil. The State of Montana permit set an upper concentration limit of 1,300 mg/kg total petroleum hydrocarbons for soil allowed to be treated in the unit.

A number of investigations and interim actions have been conducted at the Yale Oil Facility (DEQ 2005), including:

- In January 1985, the Yale Oil facility was listed on CERCLIS.
- In 1985, petroleum product in the No. 5 fuel oil tank bottom left on site spilled onto the ground. Follow-up site investigations were conducted by EPA and Exxon Corporation.
- In 1986, MDHES completed a CERCLA preliminary assessment.
- In February and March of 1986, EPA consultants and MDHES conducted a CERCLA site investigation to characterize the nature of groundwater contamination associated with the facility and to characterize waste materials found in the sludge and contaminated soils. Sample results indicated high concentrations of PAHs, 2-methylphenol and 4-methylphenol (phenols) in on-site soils and sludges and contamination of the on-site shallow alluvial groundwater with phenols and petroleum hydrocarbons. PCP was detected in groundwater from a background monitoring well and may have originated from another source. Lead and zinc were detected at elevated concentrations in an on-site soil sample. Split samples were collected by Exxon's consultant.
- In June 1986, a follow-up sampling event was conducted by EPA consultants and MDHES to identify and characterize the potential for dioxin contamination in soils and waste material and determine the potential for direct contact with contamination. However, the data from this sampling event were not reported. Exxon's consultant collected split samples and reported detectable concentrations of dioxin and furan compounds in soil samples.
- In June 1989, MDHES consultants completed a site inspection decision sheet, which identified the waste type at the facility as a nonhazardous substance under CERCLA and the nature of the release as observed but below the HRS release threshold. The facility was determined to be "No Further Remedial Action Planned" under CERCLA.

- In 1989, Exxon consultants prepared a remediation plan and conducted a test burn to determine the safety and effectiveness of using thermal desorption on contaminated soils at the facility.
- In August 1993, DEQ noticed Exxon Corporation as a PLP for the facility.
- In June 1993, EPA consultants conducted a CERCLA site inspection prioritization to review existing data and identify whether data gaps exist with regard to HRS scoring and to provide sufficient documentation for a determination of potential human health and environmental impacts.
- In 1993, Exxon conducted a voluntary cleanup action consisting of removing the tank bottom and the sludges within the tank bottom plus the contaminated soils associated with the tank bottom. Piping and stained soils associated with the piping were also excavated and thermally desorbed. More than 200 cubic yards of soil was not thermally desorbed because the TPH concentrations were above 1,300 parts per million (ppm), which was the maximum level allowed for thermal desorption by the DEQ-issued permit. These soils were stockpiled on site.
- In 1994 and 1995, Exxon consultants conducted quarterly groundwater monitoring of facility wells. Samples were analyzed for gasoline and diesel-range organic compounds, phenols, and SVOCs. Phenols were detected in samples from monitoring wells on the facility.
- In 1997, the soils that were stockpiled in 1993 were removed to an unknown disposal facility. Confirmation samples taken from the area where the stockpiled soils were stored showed 423 ppm diesel range organics (DRO), which was above the DEQ-established cleanup level at the time of 100 ppm. There is no information in the file to determine if the soils were ever excavated and disposed of at an approved facility.
- In August 1997, DEQ entered into a prospective purchaser agreement with Kalispell Partners and later voided it because of numerous violations on the part of Kalispell Partners.
- In April 1998, DEQ entered into a Settlement Agreement with Kalispell Partners.
- In November 2000 and May 2002, Exxon consultants conducted groundwater monitoring of facility wells. Samples were analyzed for extractable petroleum hydrocarbons (EPH) and volatile petroleum hydrocarbons (VPH) constituents. Some EPH and VPH constituents were detected above screening levels.
- In July 2004, DEQ filed a lawsuit naming the noticed PLP as a defendant. In the lawsuit, DEQ requested reimbursement of its oversight costs and a court order requiring the defendants to conduct remedial actions. DEQ's CECRA program is acting as the lead agency for the facility and has ranked it a medium priority.
- In December 2005, Tetra Tech prepared a DSR on behalf of DEQ.
- In March 2006, TtEMI prepared the RIWP (TtEMI 2006) on behalf of DEQ.
- In April 2006 through August 2006, TtEMI conducted RI field work to collect data for the RI report.

## SUMMARY OF PREVIOUS AND ONGOING INVESTIGATIONS

Numerous investigations were conducted at and in the vicinity of the KRY Site between August 1983 and April 2005 (Table 1-1). Data from these investigations were reviewed, summarized, and presented in the DSR (TtEMI 2005) dated December 2005. All historical data are included in Appendix G and are presented and discussed, as appropriate, in Section 4. Listed below are investigations that have been conducted since the DSR was finalized.

- In October 2005 and April 2006, BNSF consultants conducted semi-annual groundwater sampling of monitoring wells associated with the KPT facility. Available data are included in Appendix G and presented along with other historical data in Section 4.
- In November 2005, Western Research Institute (WRI), in cooperation with DEQ, conducted groundwater and soil sampling to evaluate natural attenuation and biodegradation at the KRY Site. A report summarizing these activities is included as Appendix A.
- In November 2005, BNSF consultants conducted monitoring well installation, soil borings, and surface soil sampling at the KPT and Reliance facility areas. Available data are included in Appendix G and presented along with other historical data in Section 4.
- In December 2005 and January 2006, NTL Engineering and Geoscience (NTL) conducted monitoring well installation, soil boring sampling, and groundwater sampling in the Seaman Shelton site (near Northern Energy Propane) and the Wal-Mart area east of the Yale Oil facility. Available data are included in Appendix G and presented along with other historical data in Section 4..
- In March 2006, TtEMI prepared the RIWP (TtEMI 2006) on behalf of DEQ.
- In April 2006 through August 2006, TtEMI conducted RI field work to collect data for the RI report.
- In August 2006, DEQ began recording monthly groundwater levels from monitoring wells associated with the KRY Site.
- In September 2006, BNSF consultants modified the design of the ozone treatment system at the KPT facility after review of preliminary RI analytical results for groundwater without DEQ approval or oversight.
- In October 2006, DEQ sampled five nearby residential wells to follow-up on pentachlorophenol detections observed from the RI sampling event. Pentachlorophenol was not detected in any of the samples collected from these residential wells. Available data are included in Appendix G. Samples will be collected from the five wells on a quarterly basis for a minimum of one year.

## **2.0 INVESTIGATION PROCEDURES AND FIELD METHODS**

This section describes the procedures used to collect data during KRY RI field activities, including utility clearance, monitoring well installation and development, sampling methods and equipment, water level and flow measurements, sample handling and custody, aquifer testing, surveying, analytical program and data validation, and management of investigation-derived waste. This section also describes any deviations from the investigation procedures and field methods outlined in the RIWP (TtEMI 2006), as well as the rationale for the deviations.

Sampling requirements for this project called for collecting and analyzing samples from groundwater, surface water, sediments, and soil. Coordination with all property owners within and outside the KRY Site boundary was important for sampling access and site information. Field activities followed the procedures and methods detailed in the RIWP (TtEMI 2006), except where noted, and were carried out in accordance with TtEMI's health and safety plan for the KRY Site. Copies of field logs are included in Appendix B, and a photographic log is included in Appendix C. Figures 2-1 and 2-2 show the sampling locations completed as part of this RI.

### **2.1 MOBILIZATION AND UNDERGROUND UTILITY LOCATION AND CLEARANCE**

Mobilization activities began on April 10, 2006. Sample locations were marked with stakes. Brush and vegetation were cleared from areas within the Reliance facility fenced area to make room for equipment staging, a storage trailer, water treatment, and drum storage. A secondary containment area was prepared for the water treatment system first by leveling the area, constructing a 2 ft high soil berm, and then covering the area with a polyvinylchloride liner. The berm was constructed around the water treatment area using approximately 4-5 inches of soil removed from within the treatment area. The treatment area location is in the vicinity of historical sample locations J8 and K7 (Figure E-2 of DSR [TtEMI 2005]) and activities likely disturbed surface soil conditions at these two locations. However, these samples will not be relied upon for decision making since there are other adjacent samples that provide adequate analytical information. Other activities within the staging area including clearing of brush and minor ground leveling could have disturbed other historical soil sampling locations however; soil movement in these locations was minor. Water treatment equipment including an ozone generator, generator storage shed, stock tanks, pumps, hoses, piping, and three 3,000 gallon poly tanks were placed within the lined, secondary treatment area. Electrical power was connected to the water treatment storage shed and storage trailer.

Preliminary utility locations were evaluated by reviewing several information sources, including the following:

- Evergreen Water and Sewer District (underground water line maps)
- Qwest (underground phone lines)
- AT&T Broadband (underground cable lines)
- Flathead Electric (underground electrical lines)
- Northwestern Energy (underground gas line maps)
- Site walk-throughs with property owners and operators

Before drilling began, the Montana One Call (UDIG) service was notified of drilling locations. The one call service then notified utility companies in the area, and representatives for the utilities would clear each location in the field before drilling began. The Evergreen Water and Sewer District and Northwestern Energy were also consulted directly when sampling and drilling occurred near the utilities. Northwestern Energy representatives were on site when drilling occurred in the vicinity of gas lines. All information was reviewed to identify proposed sample locations that might intersect or otherwise interfere with known utility corridors.

## **2.2 SOIL SAMPLING PROCEDURES**

The following sections describe the sampling methods and equipment used for collecting surface and subsurface soil samples. Any deviations from the work plan are included in each subsection.

### **2.2.1 Surface Soil Sampling**

Sampling surface soils followed the procedures in standard operating procedure (SOP) 005 (Appendix B of the RIWP, TtEMI 2006). Sample locations are shown on Figure 2-1. Grab surface soil samples were collected within the boundary of the KRY Site and surrounding industrial and commercial properties at a depth between 0 and 6 inches or between 0 and 2 inches below ground surface (bgs) using a new disposable trowel that was sealed in plastic. Residential surface soil samples were also collected in the same manner from neighborhoods adjacent to the KRY Site between 0 and 2 inches bgs. Samples were analyzed either for the standard suite of analytes (see Table 2-1), metals, dioxins and furans, synthetic precipitation leaching procedure (SPLP), or for a combination of these analytes. SPLP samples were analyzed for SVOCs, VOCs, and metals after SPLP extraction. A subset of surface soil sampling locations required samples from two additional depth intervals: 0.5 to 1.0 feet bgs and 1 to 2 feet bgs. A

decontaminated shovel was used to achieve the appropriate depth and a new disposable trowel was used to collect the sample. These deeper surface soil samples were analyzed for dioxins and furans, and PCP only. If present at surface soil sampling locations, vegetation, wood chips, or railroad ballast material (in the case of samples collected in the railroad right-of-way) that were not visibly contaminated, were removed before sampling. A new disposable trowel was then used to collect the soil and place it into a glass sample container.

Three surface soil samples (0 to 2 inches) were collected to establish background concentrations in soils. The proposed maximum number of background soil samples (three) and their locations were approved by DEQ prior to sampling. Background samples were analyzed for the standard suite of analytes, metals including tetraethyllead, and dioxins and furans. Representative background soil sample locations were selected based on a review of aerial photographs and current site conditions to select natural, undisturbed, or non-industrialized areas such as parks or naturally timbered areas. Sample receipts for individual property owners were completed for all samples collected on privately owned land.

**Deviations from the RIWP.** The following deviations from the RIWP are noted for surface soil sampling:

- The surface soil sample from 1 to 2 feet bgs at sampling location KRY440 was not collected because a compacted layer of cobbles and gravel was present at 1 foot bgs. Refusal was met with hand digging tools; therefore, the sample was collected when the adjacent monitoring well was installed to the east, KRY105A. The hollow-stem auger (HSA) drill rig was used to reach the 1- to 2-foot depth interval, and a new disposable trowel was then used to collect the sample.
- One surface soil location, KRY484, was moved approximately 35 feet east of its original location to avoid wood chip waste and collect a sample of undisturbed soil.
- One new surface soil sampling location was added during field work. Before borehole KRY666 was drilled (see Section 2.2.2), an opportunistic surface soil sample was collected from 0 to 2 inches bgs.

### **2.2.2 Subsurface Soil Sampling**

Boreholes on the KRY Site were completed using an HSA drill rig. Subsurface soil samples were collected with a split-spoon sampler using the procedures described in SOP 005 (Appendix B of the RIWP, TtEMI 2006). Soil borings were continuously cored and obtained using a split-spoon sampler or a Dames and Moore sampler. Soil sample lithology was classified using the Unified Soil Classification System (USCS). Borehole logs are included in Appendix D. Sampling locations are shown on Figure 2-1. Soil samples were collected by immediately placing a section of the soil core selected for analysis into a glass sample container. A portion of the sample was also placed into a Ziploc bag and warmed in the

sun to measure headspace soil gas using a portable flame ionization detector (FID) and photoionization detector (PID). The entire core was first placed into a Ziploc for FID/PID measurements if soil recovery was low because of the lithology of the site. Once headspace readings had been obtained, the sample was removed from the Ziploc and transferred to a glass sampling container.

As specified in Table F-1 of the RIWP (TtEMI 2006), subsurface soil samples were collected at depth intervals of 4 to 6 feet bgs, 8 to 10 feet bgs, and at the smear zone (from 2 feet above the water table to the water table) if field screening measures (FID/PID or visual and olfactory observations) indicated the presence of contamination. Subsurface soil samples were only collected at the smear zone at some borehole locations if contamination was evident by the field screening techniques. Subsurface samples were analyzed for the standard suite of analytes (see Table 2-1), metals, dioxins and furans, synthetic precipitation leaching procedure (SPLP), or a combination. SPLP samples were analyzed for SVOCs, VOCs, and metals after SPLP extraction.

**Deviations from the RIWP.** The following deviations from the RIWP for subsurface soil sampling are noted:

- Large boulders prevented advancement of the drill bit at two borehole locations, and the HSA rig was required to move from the original staked location. Borehole KRY610 was moved 12 feet southwest of the stake, and borehole KRY617 was moved 10 feet west of the stake. Both boreholes were completed at these new locations.
- Soil boring KRY604 was moved east from its original location to avoid overhead power lines.
- Borehole KRY661 was not drilled because of its proximity to the fence that encloses the former excavation area on the KPT facility; the HSA rig was unable to span the railroad tracks to complete the boring.
- Six new borings were added during field work.
  - Three borings were completed (KRY667, KRY669, and KRY670) to better define the extent of contamination on the KPT facility. Two opportunistic subsurface soil samples were collected from borehole KRY667 (9 to 14 and 16 to 19 feet bgs). There was no evidence of contamination at borehole KRY669 and one SPLP sample was collected (14 to 19 feet bgs) that would likely be representative of low level contamination conditions. There was no evidence of contamination at borehole KRY670, and an opportunistic sample was not collected.
  - Soil recovery was poor during the initial drilling on the northern portion of Reliance, and so two additional borings were completed later to acquire better sample volume (KRY671 and KRY672). Two subsurface soil samples were collected from KRY671 (3.5 to 5 and 8 to 9.5 feet bgs) and three samples were collected from KRY672 (4.5 to 6, 9 to 10.5, and 12 to 13.5 feet bgs).

- An additional boring, KRY666, was drilled south of the Yale facility to delineate the edge of fill material and to obtain subsurface soil samples from native soil. Three subsurface soil samples were collected from borehole KRY666 (4 to 5, 9 to 10, and 20 to 21 feet bgs).
- Table F-1 in Appendix F of the RIWP (TtEMI 2006) specified collecting five samples for SPLP analysis. SPLP analysis is a method used to evaluate the potential for contaminants to leach into surface water and groundwater. Table F-1 indicated that SPLP samples would be collected from sampling locations KRY509, KRY512, KRY603, KRY610, and KRY656. Samples for SPLP analysis were instead collected at four comparable locations: KRY137A (10 to 15 feet bgs), KRY657 (0 to 6 inches bgs), KRY658 (15.5 to 17 feet bgs), and KRY669 (14 to 19 feet bgs). The alternative locations were the result of limited soil volume at the proposed sampling locations. Pairing of SPLP analysis with standard suite analyses was planned but was not conducted due to an oversight when sample locations were moved. Therefore, SPLP analyses have been correlated with samples taken within the same sample interval or borehole, or from adjacent sampling locations, as appropriate.
- Twelve subsurface soil samples were proposed to be collected from six monitoring well locations (KRY107A and B; KRY121A and B; and KRY131A and B) and analyzed for physical parameters, including soil pH, plasticity, specific gravity, porosity, particle size, and moisture content. Two soil samples were to be collected from each of the six well locations: one subsurface soil sample was to be collected from the saturated zone, and one was to be collected from the unsaturated zone. The samples were to be collected by filling a 5-gallon bucket and a 1-gallon Ziploc with auger flight soil from the proposed interval.

Of the proposed six monitoring well locations, samples for analysis of physical parameters were obtained from three monitoring wells: KRY115A, KRY121A, and KRY139B. Soil was collected from 10 to 15 feet bgs and 23 to 27 feet bgs at well KRY115A, from 10 to 15 feet bgs and 24 to 28.5 feet bgs at well KRY121A, and from 38 to 42 feet bgs at KRY139B. All samples were analyzed for the parameters listed above and the results are shown in Appendix G.

- The RIWP specified two samples to be collected for analysis of total organic carbon (TOC) at monitoring well locations KRY121A and KRY131A. Monitoring well KRY131A was not completed (see below); therefore, a sample for analysis of TOC was not obtained from that location. However, two samples for analysis of TOC were submitted from well KRY121B: one from 12.5 to 15 feet bgs and one from 25 to 27 feet bgs.

### **2.2.3 Opportunistic Soil Sampling**

Opportunistic soil samples, or contingency samples, were not specifically proposed in the RIWP, but were generally identified in the planning stages to allow them to be collected when special or unexpected field conditions were encountered during the RI field sampling effort.

Opportunistic soil samples were collected in selected soil boreholes based on the results of headspace FID/PID field screening data and visual or olfactory observations. Fourteen opportunistic soil samples, including one surface soil and 13 subsurface soil samples, were collected at the KRY Site as part of the remedial investigation.

## **2.3 MONITORING WELL INSTALLATION AND GROUNDWATER SAMPLING**

This section describes well installation, well development, and groundwater sampling procedures used at the KRY Site. Deviations from the work plan are included in each subsection. Monitoring well logs are presented in Appendix D, and monitoring well construction data are shown in Table 2-2.

### **2.3.1 Monitoring Well Installation**

Monitoring wells were installed using HSA and Rotasonic drilling methods. Monitoring well locations are shown on Figure 2-2 and a corresponding grid location index is provided on Table 2-3. As proposed in the RIWP, monitoring well installations followed SOP 020 (Appendix B of the RIWP [TtEMI 2006]). All wells were completed either with the top of casing flush to the ground or with casing stick-up, as appropriate. All new KRY monitoring wells were constructed in accordance with State of Montana monitoring well standards and installed by licensed drillers from Cascade Drilling, Inc. All of the materials used in construction of the new wells were factory-sealed and did not require decontamination before they were installed. Lithologic descriptions and well construction information are documented on monitoring well borehole logs (Appendix D). Monitoring well construction information is also summarized in Table 2-2.

A total of 37 shallow monitoring wells, 20 deep monitoring wells, and 2 shallow piezometers were installed at the KRY Site. Seven of the shallow monitoring wells (KRY132 through KRY138) were completed to define the extent of LNAPL. Shallow monitoring wells (A wells) and shallow piezometers were completed in the upper portion of the unconfined aquifer. Deep monitoring wells (B wells) were constructed in the lower portion of the unconfined aquifer. The shallow piezometers were installed to measure static water level only.

Monitoring wells were constructed using 2-inch or 4-inch inside diameter (ID) Schedule 40 polyvinyl chloride (PVC) well casing with flush-threaded joints. Wells identified for aquifer testing were constructed using 4-inch ID well casing and included KRY113A, KRY139A, and KRY121B. The wells were screened using Schedule 40 slotted PVC screen with 0.02-inch factory-machined slots. A filter pack consisting of 10/20 mesh silica sand was placed in the annular spacing. Shallow monitoring wells were constructed with 20 feet of well screen. Approximately 7 feet of screen was located above the top of the water table, and approximately 13 feet of screen was located below the top of the water table. Screening the wells across the water table allows for seasonal fluctuations in groundwater elevation and for measuring the thickness of LNAPL, if present. Deep monitoring wells were constructed with 10 feet of screen located at the bottom of the unconfined aquifer and just above the underlying clay aquitard.

Initially, a 6-inch sediment trap (sump) was placed at the bottom of the well screen during construction of the first few RI monitoring wells. After significant amounts of silt and fine-grained sediments in the area geology were noted, it was determined that a 2-foot sediment trap would be added to the bottom of the screen on shallow wells and that a 5-foot trap would be installed on the deep wells.

The monitoring well screen and riser pipe were assembled and lowered through the augers (HSA) or drill casing (Rotasonic) to the desired depth. The 10/20 mesh silica sand was poured (HSA) or tremied through the augers or casing to form the filter pack. The filter pack extended at least 2 feet above the screen. The auger flights or casing were slowly raised out of the borehole as the filter pack was poured. Bentonite pellets were poured through the augers or casing and were hydrated with potable water to form an annular seal at least 2 feet thick above the filter pack. A grout mixture of 95 percent cement and 5 percent bentonite was poured or tremied through the augers or casing to create a bentonite seal to within 2 feet bgs. Concrete was then poured in the space above the grout to form a surface seal.

Wells were completed with either the top of the PVC casing flush with the ground (flush mount completion) or extending above the ground surface approximately 2 to 3 feet (stick-up completion). Most wells were constructed with a stick-up completion. Wells completed as stick-ups had a protective steel casing placed over the PVC. The steel casing was set in cement for stability and the concrete surface around the steel was sloped to drain surface water away from the well. Three-inch diameter bollards filled with concrete were installed around the stick-up completions to protect the well from traffic. Flush mount completions were installed only in areas of heavy vehicular traffic or at the property owners' request.

**Deviations from the RIWP.** The following deviations from the RIWP for monitoring well construction are noted:

- Eleven proposed monitoring well locations were relocated because of conditions encountered in the field. Wells KRY122A and KRY122B were moved southwest from the Town and Country Trailer Court to the Western Building Center property because the property was too small for the Rotasonic drill rig to operate in. Wells KRY116A and KRY116B were also shifted from their original position to accommodate the size of the Rotasonic drill rig. These wells were moved northwest to avoid being too close to Oregon Lane. KRY127A was moved slightly west from its location so that a property fence would not have to be dismantled for drilling. Wells KRY115B, KRY117A, KRY110A, and KRY118A were moved approximately 5 feet from the proposed locations because large boulders were present. Well KRY104A was moved 10 feet west after refusal was met at 16 feet bgs. Well KRY102B was moved a few feet west after the core barrel on the Rotasonic drill twisted off at 38 feet bgs. The original borehole was properly abandoned and sealed with bentonite before the well at the new location was drilled and completed.

- Four wells were not completed as originally proposed in the RIWP (TtEMI 2006). Well KRY131A was not drilled because a new existing monitoring well, NTL-MW4, was installed in its location by a consultant completing a Phase II environmental site assessment. Well NTL-MW4 was found to be acceptable as a replacement for proposed shallow well KRY131A. Well KRY131B was not drilled because the proposed location was inaccessible for the Rotosonic drilling rig as rain had flooded the access road and proposed location. Well KRY108B was not completed because not enough space was available between the building and stored lumber for the Rotosonic rig. Well KRY121C, which was to be completed in the confined aquifer, was instead installed in the lower portion of the unconfined aquifer and completed as well KRY121B. Based on information provided from previous site investigations (PTS 2000; ThermoRetec 2001), the confining unit was estimated to be present at 120 feet bgs and 15 to 51 feet thick. The confining unit at location 121C was encountered at approximately 125 feet bgs and was still present at a depth of 244 feet bgs. Drilling was terminated at this depth because of the uncertainty of the confining unit thickness and the difficulties encountered in drilling through the dense confining unit material. The borehole was grouted back to 130 feet bgs (where a 5-foot-thick bentonite layer had been poured to seal off the upper aquifer from the lower aquifer). The well was then completed as a B zone monitoring well in the lower portion of the unconfined aquifer.
- Two additional monitoring wells were added during the investigation. Shallow well KRY113A and deep well KRY113B were installed on the BNSF property north of the Klingler Lumber Company. Since well KRY108B could not be completed at its original location (see above), the KRY113 location was chosen for the shallow and deep well pair because of its close proximity to the originally planned location for the KRY108 well pair. Figure 2-2 identifies the additional well locations.
- Two shallow wells were screened below the water table to account for the presence of clay and the concern that contamination would not be detected if the wells were screened within the clay layer (in other words, that the contaminants would follow the alluvial sediments where groundwater flow was not impeded). A dense clay layer was present in well KRY130A from 15 to 30 feet bgs and the water table was reached at approximately 24 feet bgs. This well was screened from 25 to 45 feet bgs with 5 feet of screen in the clay and 15 feet of screen in sand and gravel. Clay was found at well KRY110A from 9 to 41 feet bgs with the water table present at approximately 12 feet bgs. This well was screened from 35 to 55 feet bgs with 6 feet of screen in the clay and 14 feet of screen in sands and gravel.

### **2.3.2 Monitoring Well Development**

Monitoring wells were developed in accordance with SOP 021 (Appendix B of the RIWP [TtEMI 2006]). The monitoring well was allowed to stabilize for a minimum of 48 hours after completion to allow for adequate curing of the grout. Before wells were developed, the depth to water and total depth of the well were measured using a water-level indicator. These measurements were used to calculate the well casing volume and minimum purge volume. The well was surged by manually raising and lowering a surge block through the water column for a minimum of 10 minutes. During surging, the wells were also manually bailed with a stainless steel bailer to remove the majority of the clay and silt particles. All equipment was decontaminated after each well was developed. Wells that contained LNAPL were

developed using the surge block and stainless steel bailer only until a minimum of three casing volumes had been evacuated.

After the well was surged, a portable pump was used to evacuate a minimum of three casing volumes of water from the well. Tubing attached to a Grundfos submersible pump was lowered to variable depths below the water table to evacuate the water from the well and introduce groundwater into the well from the aquifer. Water quality parameters, including pH, specific conductance, and temperature, were measured when each casing volume of water was removed to provide baseline information and were recorded on well development forms (Appendix E). Water quality meters were calibrated each day and checked periodically. Monitoring well development continued until two consecutive measurements of water quality parameters had stabilized to within 10 percent and the purge water was reasonably free of sediment, or until 10 casing volumes had been removed.

The well was allowed to recharge if it dried up before the specified amount of purge water had been withdrawn. Additional water was removed after the well had recharged, and the well was purged until a total of three well casings had been removed.

Water evacuated during well development was temporarily contained in a 500-gallon tank and then transferred to the temporary ozone treatment system tanks located on the Reliance facility, where it was subsequently treated and disposed of as investigation-derived waste (IDW). See Section 2.10 for additional information on procedures for IDW handling and disposal.

**Deviations from the RIWP.** The following deviations from the RIWP for well development are noted:

- The design of the Grundfos pump and its power requirements made it impractical to disconnect and reattach disposable tubing after each well. The Grundfos pump and associated tubing were instead decontaminated between each well by placing the equipment in a small plastic pool and steam cleaning it with Liquinox and potable water from the Evergreen Water and Sewer District. Clean water and Liquinox were also pumped through the tubing until it was decontaminated. Based on information in the borehole logs and well installation records, the wells were developed in order from the least contaminated to the most contaminated in an additional effort to eliminate the possibility of cross-contamination.

### **2.3.3 Groundwater Sampling**

Low-flow sampling was used to collect groundwater samples from all monitoring wells sampled at the KRY Site. Low-flow sampling incorporates a low pumping rate (maximum discharge equal to 0.5 liters per minute) that provides significant advantages over traditional high-rate purge or bailing sampling

methods. The objective is to minimize physical and chemical changes to groundwater during sample collection. Reducing drawdown and aeration of the water column minimizes volatilization of chemicals that may be present in the aquifer. In addition, low-flow sampling was conducted to be consistent with previous sampling methods used at the site and to minimize IDW generation. Low-flow well purging and sampling complied with procedures summarized in the April 18, 2005, *SRS Low-Flow Purging and Sampling Guidelines*, provided in Appendix B of the RIWP (TtEMI 2006).

Wells that contained LNAPL, or that could contain LNAPL, were sampled using a peristaltic pump using recommendations provided by DEQ (2006a). A peristaltic pump was used at 14 wells across the KRY Site to collect a groundwater sample below the LNAPL layer to avoid sampling free product. The 14 wells included GWRR-2, GWRR-3, GWRR-5, GWRR-6, GWRR-7, GWRR-8, GWRR-9, KPT-2, KPT-3, KPT-4, KPT-20, KPT-21, KRY114A, and PW-1. The procedure for groundwater sampling in monitoring wells that contained LNAPL is described later in this section.

Groundwater samples were collected from monitoring wells after the well had been developed (for newly installed wells) and purged (all wells). All monitoring wells without known or historical LNAPL were purged and sampled using a bladder pump. Disposable bladders and tubing were used in each monitoring well sampled, and the bladder pump was decontaminated between monitoring wells.

Observations of water level, flow rate, and the quantity and clarity of the water withdrawn were monitored during purging and recorded on groundwater sampling forms. During purging, field parameters were measured using a closed flow-through cell system. Field parameters measured included temperature, pH, conductivity, turbidity, oxidation-reduction potential (ORP), and dissolved oxygen (DO). Low-flow purging continued until temperature, conductivity, DO and pH stabilized. Parameters were considered stabilized when three or more sequential measurements were within  $\pm 0.2$  °C for temperature,  $\pm 3$  percent for conductivity,  $\pm 10$  percent for DO, and  $\pm 0.1$  unit for pH (EPA 1996). A groundwater sample was collected once field parameters stabilized.

If the stabilization parameters did not fall within the specified ranges after three well volumes had been purged, sampling proceeded and a comment was noted on the groundwater sampling data sheet (Appendix E). Water samples for laboratory analysis were collected by disconnecting the down-hole tubing from the flow-through cell and collecting the sample in labeled sample containers. The pump discharge rate was maintained at 0.5 liters per minute or less.

Existing residential and industrial wells were sampled from an outside spigot or tap located closest to the well and before any in-line water treatment system. The existing pump in each well was used for purging and sampling with the exception of residential well RW-6, where clean tubing and the peristaltic pump were used since no pump was installed in the well and it was used for irrigation purposes only.

Residential and industrial wells were purged a minimum of three well volumes, and water quality parameters were monitored before sampling. One round of groundwater samples was collected from all monitoring wells, residential wells, and industrial wells after the development and purging phase of the investigation. Samples were submitted for one or a combination of the following analysis: standard suite of analytes (see Table 2-1), dissolved metals, dioxin and furans, formaldehyde, chloride, and bromate.

Potential LNAPL wells were sampled with a peristaltic pump using the following methods. The water level and LNAPL thickness were measured to establish the sampling depth for setting the peristaltic tubing. Disposable 1-inch ID high density polyethylene (HDPE) tubing was sealed with plastic wrap at its lower end with a hose clamp. The 1-inch tubing was then lowered through the top of the water table and placed approximately 2 feet below the bottom of the LNAPL layer or static water level. A ½-inch ID piece of HDPE disposable tubing was then lowered inside the 1-inch tubing, pushed through the plastic wrap seal, and placed approximately 2 feet below the end of the 1-inch tubing. Disposable ¼-inch polyethylene tubing was then lowered through the ½-inch tubing, and the end was set approximately 1 foot below the bottom of the ½-inch tubing and in the screened interval. The well was then purged using the ¼-inch tubing connected to a peristaltic pump. Well purging used a low discharge rate, and approximately 5 gallons of water were removed before the sample was collected. Field parameters were not recorded because of the potential to damage the flow-through cell instrumentation with product.

**Deviations from the RIWP.** The following deviations from the RIWP for monitoring well sampling are noted:

- A bladder pump became lodged in monitoring well KRY130B. It appears that the sampling tubing slid down between the inside of the well casing and the bladder pump. Attempts to recover the pump failed and the pump and tubing are still stuck within the casing. A groundwater sample was therefore collected from above the pump and above the screened interval using the peristaltic pump. Prior to sampling, casing water was removed by purging three well casings of water from the well to obtain a sample representative of formation water.
- A few residential wells and one industrial well were not sampled as originally proposed in the SAP because of unforeseen field conditions. Residential wells RW-2 and RW-4 were found to be abandoned. The resident at well RW-3 stated he was unaware of a well on the property and had lived there for 7 years. A sample was not collected from well RW-5. A sample was instead collected from adjacent monitoring well NTL-MW-4 because well completion information was available. Well RW-7 was not sampled since the well pump did not have power; DEQ instructed

TtEMI not to sample this residential well. Industrial well IW-3 could not be sampled because of a blockage in the 3-inch-diameter stand pipe. No pump was present in the well. There was concern that sampling equipment would be lost if an attempt was made to sample the well.

### **2.3.4 Opportunistic Groundwater Sampling**

Ten opportunistic or contingency groundwater samples were collected during the field investigation from monitoring (KRY113A, KRY113B, GWRM-1, GWRM-2, and NTLMW-4), residential (RW-9A, RW12, and RW13), and public water supply wells (PWS-1 and PWS-2).

**Deviations from the RIWP.** No deviations were noted in collecting opportunistic groundwater samples.

## **2.4 SURFACE WATER, SEDIMENT, AND SLUDGE SAMPLING**

This section describes the field methods used for collecting surface water, sediment, and sludge samples, collecting water level and flow measurements, opportunistic sampling, and any deviations from the RIWP.

### **2.4.1 Surface Water, Sediment, and Sludge Sampling**

Samples of surface water and sediment were collocated at five locations along the Stillwater River (KRY200, KRY201, KRY202, KRY203, and KRY204) as shown on Figure 2-2. Both surface water and sediment samples were analyzed for the standard suite of analytes and metals. Surface water and sediment samples for KRY200, KRY202, and KRY203 were also analyzed for dioxins. Water quality parameters were measured at each sampling location using field sensor probes for pH, specific conductance, temperature, DO, ORP, and turbidity.

Collocated surface water and sediment samples were collected from the most downstream location (KRY204) to the farthest upstream sample location (KRY200) so that any sediment disturbed from samples collected upstream did not affect downstream sample locations. The following sequence of sampling occurred at each location:

- (1) A surface water sample was collected.
- (2) Water quality parameters were measured.
- (3) A sediment sample was collected.
- (4) River stage was measured, and the elevation tied to a known survey point.

### **Surface Water Sampling**

Surface water samples were collected as grab samples by directly immersing sample containers under the water surface near the river bank, as described in TtEMI SOP 009 (Appendix B of the RIWP [TtEMI 2006]). Surface water flows in the Stillwater River were not measured as part of the field investigation.

### **Sediment Sampling**

Stream sediment samples were collected using a core sampler, as outlined in SOP 006 (Appendix B of the RIWP [TtEMI 2006]), and the sampling location farthest downstream was sampled first. Sediment samples were obtained from slow-moving pools or eddies, where possible. Initial sediment sampling was attempted using a ponar clam shell sampler. The sediment was compact, and the clam shell sampler was unable to efficiently collect sediment. As a result, the core sampler was used to collect an undisturbed sediment sample. Aqueous samples were obtained first to avoid collecting suspended particles that may result from sediment sampling. Sampling locations were always approached from the downstream side to avoid disturbing an area to be sampled.

### **Sludge Sampling**

Sludge samples at the former Reliance facility and vicinity were collected (KRY415 and KRY422) as part of the surface soil investigation. Sample locations are identified on Figure 2-1. The sludge at the KRY Site was a fairly solidified tarry waste intermixed with soil. Sampling followed SOP 006 (Appendix B of the RIWP [TtEMI 2006]) using a stainless steel hand trowel, which was decontaminated between each use. These samples were analyzed for SVOCs, VOCs, and metals after toxicity characteristics leaching procedure (TCLP) extraction, polychlorinated biphenyls (PCBs), the standard suite of analytes, metals (KRY422 only), and dioxin and furans.

**Deviations from the RIWP.** The following deviations from the RIWP for monitoring well sampling are noted:

- Sediment and surface water sampling did not occur at the same time as other sampling due to high water conditions. This difference is not considered problematic.
- Table 7 of the RIWP indicated that sediment samples were to be analyzed for TOC while Table F-1 of the RIWP indicated that TOC analyses were not to be performed. TOC analyses were not performed on sediment samples since Table F-1 was considered to have precedence. Sediment TOC data is not considered critical to decision making since no samples contained analytes at concentrations above screening criteria.

## 2.4.2 Opportunistic Surface Water, Sediment, and Sludge Sampling

No opportunistic surface water, sediment, or sludge samples were collected during the field investigation.

## 2.5 WATER LEVEL MEASUREMENTS

This section describes the field methods used for collecting water level measurements and any deviations from the RIWP (TtEMI 2006).

### 2.5.1 Monitoring Well Water Level Measurements

Static water level measurements were collected from newly proposed and existing monitoring wells during groundwater sampling and again on July 11-12, 2006, and August 1 through 3, 2006. An interface probe was used to measure LNAPL that was more than 0.1 foot thick, if encountered. The static water level elevation was corrected for wells with LNAPL (EPA 1996) using a correction factor formula as follows:

$$H_c = h_m + (H_o(d_o/d_w))$$

where

$H_c$  = hydraulic head corrected (feet above mean sea level (ft MSL))

$H_m$  = measured elevation of hydrocarbon-water interface (ft MSL)

$H_o$  = thickness of hydrocarbon layer (ft)

$D_o$  = hydrocarbon density (for diesel = 0.872)

$D_w$  = water density (assumed = 1.0)

Static water levels were measured in monitoring wells according to the procedures outlined in SOP 014 (Appendix B of the RIWP [TtEMI 2006]). A water-level probe attached to a measuring tape and reel was lowered into a well until the audible alarm sounded. A measurement was taken by reading the depth from the graduated tape from a measuring point mark located on the north side of the top of the PVC well casing. Monitoring well water-level measurements are summarized in Section 3.6.3.

**Deviations from the RIWP.** There were no deviations from the RIWP for water level measurements in monitoring wells.

## **2.5.2 Surface Water Level Measurements**

Surface water levels were collected at surface water monitoring stations KRY200, KRY201, KRY202, KRY203, and KRY204. Surface water measurements were collected by measuring the vertical distance from a surveyed station (rebar stakes) adjacent to each sample location to the water surface, following SOP 052, SOP 090, or SOP 095 (Appendix B of the RIWP [TtEMI 2006]).

**Deviations from the RIWP.** There were no deviations from the RIWP for surface water level measurements.

## **2.5.3 Opportunistic Water Level Measurements**

No opportunistic water level measurements were collected during the field investigation.

## **2.6 AQUIFER TEST METHODS**

Aquifer pumping tests were conducted on six paired monitoring wells to estimate the hydraulic parameters of the aquifer. Aquifer tests were conducted on four monitoring wells completed in the upper portion of the unconfined aquifer and on two monitoring wells completed in the lower portion of the unconfined aquifer and included KRY121A, KRY121B, KRY113A, KRY108A, KRY139A, and KRY139B. The aquifer tests were conducted as short-duration (typically less than 100 minutes) pumping tests to limit the amount of contaminated discharge water that required containment and treatment. Aquifer test analyses are provided in Appendix I and test results are discussed in Section 3.6.4.

Aquifer pumping tests were conducted after the wells had been developed and sampled. The duration of the tests ranged from 42 minutes to 112 minutes, depending on well yield. Aquifer pumping tests were conducted by pumping the test well at a constant discharge rate with a submersible pump and recording water level drawdown and recovery in the pumping well and observation wells. Maximum pumping rate for the 2-inch diameter wells (KRY121A, KRY113B, KRY108A, and KRY139B) was 6 gallons per minute (gpm) and was limited by the size of the pump that could be installed in a 2-inch diameter well. Maximum pumping rate for 4-inch diameter well KRY121B was 30 gpm. The maximum pumping rate for 4-inch diameter well KRY139A was 5.8 gpm because increasing the pumping rate at this location resulted in excessive drawdown. Approximately 5,500 gallons of water was generated during aquifer testing, which was contained and subsequently treated in the on-site ozone treatment system

An aquifer pumping test at location KRY113A could not be completed because the water level drew down rapidly to the top of the pump at a pumping rate of 1.5 gpm. The cause of this anomalous drawdown was uncertain. Consequently, a shallow well aquifer test was conducted at location KRY108A, which is located close (within 75 feet) to well KRY113B.

Fluctuations in water level were recorded using an In-Situ Mini-Troll 30 pounds per square inch (psi) pressure transducer and electronic data logger. The measurement resolution or accuracy of the In-Situ 30 PSI Mini Troll pressure transducer readings is rated at plus or minus 0.1%. A pressure transducer was installed in the pumping well and the two closest observation wells. All data collected by the data logger were downloaded to a laptop computer after the test was complete. The data were analyzed using AQTESOLV 4.0 aquifer test software using the Cooper and Jacob (1946) method (HydroSOLVE 2006).

**Deviations from the RIWP.** The following deviations from the RIWP for the aquifer tests were noted:

- Since monitoring well pair KRY131A/KRY131B was not installed, aquifer tests on the eastern portion of the investigation area were completed in monitoring wells KRY139A/KRY139B.
- Monitoring well KRY 108A was used to replace nearby monitoring well KRY 113A since monitoring well KRY 113A did not produce enough water to conduct a short-duration aquifer test.

## **2.7 SAMPLING HANDLING AND CUSTODY**

The following subsections describe sample handling procedures, including sample identification and labeling, documentation, chain-of-custody, and shipping. Deviations from the RIWP are included in each section.

### **2.7.1 Sample Identification**

A unique sample identification number was assigned to each sample collected at the KRY Site. The sample identification numbering system was designed to be compatible with the TtEMI computerized data management system that includes results from previous investigations conducted at the KRY Site. The sample numbering system allows each sample to be uniquely identified and provides a means of tracking the sample from collection through analysis.

Each sample was assigned an alpha-numeric identification number, where the first alpha characters indicated the investigation site (KRY), the second three numeric characters (XXX) identified the sampling station number, the third alpha character (W) indicated the well completion depth (for

monitoring well locations only), the fourth set of alpha characters (QQ) identified the sample media, and the last three numeric characters (ZZZ) indicated the sample number. The first number of ZZZ was assigned the number 7 for groundwater field duplicate samples. The sample numbering scheme is summarized in the table.

<u>Site</u>	<u>Station Number and Sample Media</u>	<u>Sample Number</u>
KRY	XXXWQQ	ZZZ

Sample media (QQ) include:

- SB – Soil Boring/Subsurface Soil
- GW – Monitoring Well/Groundwater
- SS – Surface Soil/Sludge
- SE – Sediment
- SW – Surface Water

The field QC samples for this investigation include equipment rinsate blanks, source water blanks, and IDW confirmation samples. The station types for quality control samples include:

- QE – Equipment Rinsate Blank
- QS – Source Water Blank
- QI – IDW Confirmation Sample

Unique station numbers (XXXW) were assigned for newly proposed KRY Site stations, as follows.

- KRY groundwater stations, including surface soil and subsurface soil samples collected at monitoring well locations KRY100 through KRY199

The well completion depth (W) pertains to soil samples collected during installation of the monitoring well and all subsequent groundwater samples, and includes:

A – Designation for a new monitoring well completed in the upper portion of the unconfined aquifer

B – Designation for a new monitoring well completed in the lower portion of the unconfined aquifer

- KRY collocated surface water and sediment stations KRY200 through KRY299
- KRY stations where only surface soil samples were collected: KRY400 through KRY599
- KRY stations where subsurface soil samples were collected (also applied to associated surface soil samples collected in conjunction with the borehole): KRY600 through KRY699

- KRY IDW samples KRY800 through KRY899
- KRY source water samples KRY900 through KRY999

Existing groundwater monitoring wells, industrial wells, and residential wells were sampled as part of this investigation. Station numbers for these existing wells retained the monitoring well number previously assigned, but KRY was added to the beginning of the sample number to prevent duplication errors in the data management system.

The sample number (ZZZ) for groundwater samples pertained to the sample event. For example, the sample number (ZZZ) was 001 (field duplicate is 701) for the first round of groundwater sampling conducted as part of this field investigation. The sample number (ZZZ) will be 002 (field duplicate is 702) for the next subsequent round of sampling (if conducted).

The sample number (ZZZ) for all soil samples pertained to the specific depth interval sampled and is numbered sequentially from the surface to the deepest sample interval at a specific sample point. For example, if three subsurface soil samples were collected from a single soil boring, the shallowest sample was assigned a sample number (ZZZ) of 001, the next deepest sample was assigned a sample number (ZZZ) of 002, and the deepest sample was assigned a sample number (ZZZ) of 003.

Therefore:

- The groundwater sample collected during the first round of sampling at newly proposed monitoring well KRY123A would be designated as KRY123AGW001. The field duplicate for this sample would be KRY123AGW701.
- The groundwater sample collected during the first round of sampling as part of this RI field investigation at existing monitoring well GWRR-9 was designated KRYGWRR9GW001. If a field duplicate had been collected, it would have been KRYGWRR9GW701.
- The subsurface sample collected from the 4 to 6 feet bgs depth interval at soil boring location KRY623 was designated KRY623SB002 (assuming there was one shallower sample interval from this same borehole). The next deepest sample from this borehole (8 to 10 feet bgs) was designated KRY623SB003.
- The three surface soil samples (0 to 0.5 foot bgs, 0.5 to 1 foot bgs, and 1 to 2 feet bgs) collected at surface soil location KRY405 were designated KRY405SS001, KRY405SS002, and KRY405SS003.

**Deviations from the RIWP.** The following deviations from the RIWP are noted for sample identification.

- The alpha-numeric identification number was modified from the numbering scheme proposed in the RIWP (TtEMI 2006). The station type (QQ) was not listed first; instead, the investigation site

(KRY) was inserted at the beginning of each sample name. The station type was listed after the station number (XXX), as discussed above.

- Duplicate groundwater samples were designated with a 700 series number instead of a 900 series, as originally proposed in the RIWP.
- Instead of a three separate number series for a location where multiple media types were collected, the monitoring well or borehole station number took precedence for all samples obtained from the location. For example, as originally proposed in the RIWP, monitoring well station KRY108A was also subsurface soil station KRY642 and surface soil station KRY488. To reduce confusion, all samples collected from that one sampling point were identified with monitoring well designation KRY108A (for example, KRY108ASS001, KRY108ASB001, and KRY108AGW001).

### **2.7.2 Sample Labels, Documentation, Shipment, and Chain of Custody**

All samples collected as part of the RI field investigation were handled as specified in the RIWP (TtEMI 2006) Sections 2.3.2 through 2.3.5 of the sampling and analysis plan (SAP).

**Deviations from the RIWP.** No deviations from the RIWP were noted for sample labels, sample documentation, shipment, or chain of custody.

### **2.7.3 Sample Quality Control**

TtEMI assessed the quality of field data through regular collection and analysis of field QC samples. Laboratory QC samples were analyzed in accordance with referenced analytical method protocols to ensure that laboratory procedures and analysis were conducted properly and that the quality of the data was known. An assessment of field and laboratory sample quality control and overall data quality is provided in Appendix H.

#### **2.7.3.1 Field Quality Control Samples**

QC samples are collected in the field and analyzed to check sampling and analytical precision, accuracy, and representativeness. The following section discusses the types and purposes of field QC samples that were collected for this project. Table 2-3 provides a summary of the types and frequency of collection of field QC samples.

### **Field Duplicates**

Field duplicate samples are collected at the same time and from the same source and then submitted as separate samples to the laboratory for analysis. Field duplicates were collected at a frequency of 5 percent for water samples. Duplicate samples were assigned a unique sample identification number (700 series) and time that do not obviously indicate that it is a duplicate.

Although field duplicate soil samples are sometimes collected as soil samples from adjacent locations, these soil duplicate samples were not collected for this project for two reasons. First, since adjacent soil samples incorporate some spatial variability, these samples cannot be used directly to assess sampling precision. Second, it is not practical to set QC limits for the relative percent difference of these samples, which precludes their use for QC.

### **Source Water Blanks and Trip Blanks**

Contamination can be introduced from many external sources during collection of field samples, including water used in the decontamination process. Source water blanks (water used for decontamination) were collected from each source where water was obtained for decontamination or quality control and prepared by the field team at a frequency of 1 per 20 samples (5 percent) to assess potential external sources of contamination. Potable water from Evergreen Water and Sewer District was primarily used for the decontamination process. Culligan deionized water was also used for decontamination and for the collection of equipment rinsate samples (inorganic analyses only, as identified in the RIWP). Analytically certified, organic-free, laboratory-grade water provided by Energy Laboratories, Inc. (ELI), was used during the collection of equipment rinsate samples for the organic analyses. All three sources were submitted as source water blanks; Evergreen and Culligan water was analyzed for the standard analyte suite, metals, dioxins and furans, formaldehyde, chloride, bromate, and PCBs. (Note that only Culligan water was analyzed for PCBs based on the samples and source water being submitted that day). The ELI laboratory-grade water was analyzed for the standard suite of analytes and metals.

Trip blanks are similar to source water blanks but specific to analysis of VOCs and included during shipment to verify that shipping does not contribute to contamination. Trip blanks were previously prepared by the laboratory in 40 milliliter volatile organic analysis (VOA) bottles, and were returned to the laboratory for analysis of VOCs. Trip blanks were included in each shipment with samples analyzed for VOCs.

If any contaminant was present in the blank samples above the method detection limit (MDL), the result for associated field samples that contain the same contaminant was qualified as potentially not detected if the concentration of the field sample was less than five times the concentration found in the blank. The same criterion applies to the following common laboratory contaminants when they are present in the associated field sample at less than 10 times the concentration found in the blank sample: methylene chloride, acetone, 2-butanone, and phthalate esters.

### **Equipment Rinsate Samples**

Equipment rinsate samples demonstrate whether decontamination procedures are effective in removing contaminants from the field sampling equipment. The presence of contamination in equipment rinsate samples indicates that cleaning procedures were not effective, allowing for the possibility of cross-contamination. Equipment rinsate samples were collected during soil and water sampling at a frequency of 5 percent. An equipment rinsate is a sample collected after a sampling device is subjected to standard decontamination procedures. Water was poured over or through the decontaminated sampling equipment into a sample container and sent to the laboratory for analysis. Analytically certified, organic-free, high-performance liquid chromatography-grade water or equivalent was obtained from ELI and used for organic parameters; deionized or distilled water obtained from Culligan and was used for inorganic parameters.

Equipment rinsate samples were sent to the laboratory for analysis. The results for the equipment rinsate samples were used during data validation to qualify data or to evaluate the levels of analytes in the field samples collected on the same day.

**Deviations from the RIWP.** There were no deviations from the work plan for field duplicates or when source water, trip blanks, or equipment rinsate samples were collected and submitted.

### **2.7.3.2 Laboratory Quality Control Samples**

Laboratory QC samples are prepared and analyzed at the laboratory to evaluate the effectiveness of sample preparation and analysis and to assess analytical precision and accuracy. The types of laboratory QC samples that were used for this project are discussed in the following sections. Appendix A of the RIWP (TtEMI 2006) presents project-specific precision and accuracy goals for these samples.

### **Matrix Spike and Matrix Spike Duplicates**

Matrix spike and matrix spike duplicate (MS/MSD) samples require collection of an additional volume of material for laboratory spiking and analysis. MS/MSD samples were collected at a frequency of 5 percent for soil and water (designated on the chain of custody by the sample coordinator). MS/MSD samples were also selected by ELI to satisfy internal standards. Matrix spike samples measure the efficiency of all the steps in the analytical method in recovering target analytes from an environmental matrix. The percent recoveries were calculated for each of the spiked analytes and used to evaluate analytical accuracy. The RPD between spiked samples was calculated to evaluate precision. Project-specific precision and accuracy goals are presented in Appendix A of the RIWP (TtEMI 2006).

### **Method Blanks**

Method blanks were prepared to evaluate whether contamination originated from the reagents used in sample handling, preparation, or analysis. Method blanks are critical in distinguishing between low-level field contamination and laboratory contamination. Method blanks consisted of laboratory analyte-free water and all of the reagents used in the analytical procedure. It was prepared for every analysis in the same manner as a field sample and is processed through all of the analytical steps. Method blanks were prepared at the frequency prescribed in the individual analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method.

### **Laboratory Control Samples or Blank Spikes**

A laboratory control sample (LCS), or blank spike, originated in the laboratory as deionized or distilled water that had been spiked with standard reference materials of a known concentration. An LCS was analyzed to verify the accuracy of the calibration standards. These internal QC samples were also used to evaluate laboratory accuracy in the presence of matrix interference for field samples. LCSs were processed through the same analytical procedure as field samples. LCSs were analyzed at the frequency prescribed in the analytical method or at a rate of 5 percent of the total samples if a frequency is not prescribed in the method. Laboratory-specific protocols were followed to gauge the usability of the data if percent recovery results for the LCS or blank spike were outside of the established goals.

### **Surrogate Standards**

Surrogate standards consisted of known concentrations of nontarget organic analytes that were added to each sample, method blank, and MS/MSD before samples were prepared and analyzed. The surrogate

standard measured the efficiency of the analytical method in recovering the target analytes from an environmental sample matrix. Percent recoveries for surrogate compounds were evaluated using laboratory control limits. Surrogate standards provided an indication of laboratory accuracy and matrix effects for every field and QC sample that is analyzed for volatile and extractable organic constituents. Surrogate compounds were used in the analysis of VOCs to monitor purge efficiency and analytical performance, whereas surrogates were used in the analysis of extractable organic compounds to monitor the extraction process and analytical performance.

Factors such as matrix interference and high concentrations of analytes may affect surrogate recoveries. The effects of the sample matrix are frequently outside the control of the laboratory and may present unique problems. Laboratory personnel are required to re-extract (when applicable) and re-analyze samples when associated surrogates are outside of control limits. Data from both analyses of the samples in question are reported during the data validation process.

Data were qualified as estimated during validation for any result that failed to meet surrogate criteria. SVOC data were qualified as estimated if two or more surrogates from each fraction (base/neutral and acid) were outside the control limits. The table in Appendix A of the RIWP (TtEMI 2006) provided the guidelines for surrogate recovery for analyses that were completed for this project.

### **Internal Standards**

Internal standards are compounds that were added to every VOC and SVOC standard, method blank, MS/MSD, and sample or sample extract at a known concentration prior to analysis. Internal standards were used as the basis for quantification of gas chromatograph/mass spectrometer (GC/MS) target compounds and ensure that the GC/MS sensitivity and response are stable during the analytical run. An internal standard was used to evaluate the efficiency of the sample introduction process and monitored the efficiency of the analytical procedure for each sample matrix encountered. Internal standards were also used in the analysis of organic compounds by GC to monitor retention-time shifts. Validation of internal standards data was based on EPA protocols presented in guidelines for evaluating organic analyses (EPA 1999).

**Deviations from the RIWP.** There were no deviations from the work plan for laboratory quality control samples

### **2.7.3.3 Additional Laboratory Quality Control Procedures**

In addition to the analysis of laboratory QC samples, subcontractor laboratories conducted additional QC procedures as outlined in each laboratory quality control plan. A summary of laboratory quality control is provided in Appendix H.

**Deviations from the RIWP.** There were no deviations from the work plan for additional laboratory quality control procedures.

## **2.8 STATION LOCATIONS AND SURVEY**

The locations of newly constructed monitoring wells, as well as all newly installed surface water stations, were surveyed by Montana Mapping Associates of Kalispell, Montana, to an accuracy of plus or minus 0.1 foot horizontally and plus or minus 0.01 foot vertically. The survey was conducted using National Geodetic Vertical Datum 1988 (NAVD88) for vertical elevations and Montana State Plane Coordinates North American Datum 1983 (NAD83), United States feet, for horizontal locations. Vertical coordinates were reported as feet above mean sea level. Horizontal and vertical measurements were recorded for the top of well casing and for ground surface immediately adjacent to the well at all monitoring wells. Horizontal and vertical measurements were recorded for the top of the rebar stakes at all surface water stations. In addition, some landmarks (building corners and USGS section corners) were surveyed to ensure accurate overlays of sampling locations with aerial photography used for the figures in this report.

The locations of all other soil sampling locations (surface soil and borehole) were measured using a hand-held GPS unit. The sampling points were located using a Garmin GPS V unit and marked with a stake. The same GPS unit was used to record sampling points if they deviated from the original staked location or if a location had not been previously staked. The GPS locations and survey results are presented in Appendix F.

**Deviations from the RIWP.** Existing monitoring well locations were not surveyed at the direction of DEQ. Survey data provided by RETEC and historical data from former investigation reports were used to locate previously installed monitoring wells and sampling stations. Elevation data provided by RETEC were used to establish measuring points for previously installed wells.

## **2.9 ANALYTICAL PROGRAM AND DATA VALIDATION**

Samples obtained for laboratory analysis were collected and analyzed according to the procedures outlined in the RIWP (TtEMI 2006). Laboratory analytical data were evaluated for quality following data validation procedures established by EPA, including “National Functional Guidelines for Organic Data Review” (EPA 1999) and “National Functional Guidelines for Inorganic Data Review” (EPA 1994). Data that were collected during the RI sampling program were validated by a TtEMI chemist. The quality of the data was assessed through the use of field and laboratory QC samples, which were collected at regularly scheduled intervals as described in the RIWP (TtEMI 2006). Laboratory analytical results are presented in Appendix G. Appendix H contains data validation reports and an assessment of field and laboratory sample quality control.

**Deviations from the RIWP.** No deviations from the RIWP were noted for the analytical program and data validation procedures.

## **2.10 MANAGEMENT OF INVESTIGATION-DERIVED WASTE**

A substantial quantity of IDW was generated during this investigation. Solid matrix IDW included drill cuttings, the remainder of homogenized soil from sampling, contaminated disposable equipment, contaminated disposable personal protective equipment, and sediment separated during liquid IDW treatment. Liquid matrix IDW included wastewater from decontamination procedures, monitoring well development and purging, aquifer testing, and preparation of equipment rinsate samples.

### **Solid Matrix IDW**

Soil cuttings and other solid matrix IDW were stored in 55-gallon drums on site, and the associated soil sample identification numbers were marked on each drum using an indelible ink pen. An estimated 2,500 cubic feet (93 cubic yards) of solid matrix IDW was generated. Once the analytical results from the sample location were received, they were used to segregate IDW soil into two groups. Drums that contained soil with concentrations of PCP greater than 0.01 milligrams per kilogram (mg/kg) (the EPA Soil Screening Level [SSL] with a dilution attenuation factor [DAF] of 10 – the most stringent of the screening criteria) were considered RCRA listed waste (EPA code F032) and were shipped off-site to a RCRA treatment storage and disposal (TSD) facility on November 8, 2006. Drums that contained soil with concentrations of PCP less than 0.01 mg/kg were not considered RCRA listed waste.

Drums were segregated into two groups when no analytical results were available for PCP. The drums with soils that were considered likely to contain PCP at concentrations greater than 0.01 mg/kg were considered RCRA listed waste (EPA code F032) and were shipped off site to a RCRA TSD facility. These drums included IDW as sediment from water treatment and drums with soil from locations near where PCP was detected at concentrations greater than 0.01 mg/kg. Drums with soil that were considered likely to contain PCP at concentrations less than 0.01 mg/kg were from locations near where concentrations of PCP were less than 0.01 mg/kg. After these drums were consolidated, this soil was disposed at the Flathead County landfill, which can accept petroleum-contaminated material. The landfill was provided with all available analytical data and was comfortable that the soil was appropriate for disposal without additional sampling.

Empty drums were cleaned and were stored within the fenced area at the Reliance facility, per DEQ request.

### **Liquid Matrix IDW**

An estimated 14,000 gallons of IDW wastewater was generated during this investigation. IDW wastewater generated during the RI was temporarily stored in drums or a 500-gallon portable tank and then transferred to on-site 350-gallon stock tanks, where coarse-grained sediment was allowed to settle out. IDW wastewater was then transferred to 3,000-gallon tanks and processed using media filters, a granulated activated carbon (GAC) filter, and an ozonation treatment system. After treatment, one composite IDW water sample per treatment batch (from 1,000 gallons to 6,000 gallons per batch) was analyzed for the following parameters: PCP, SVOCs (including PAHs), dioxins and furans, and EPH. Liquid matrix IDW was treated until concentrations of all contaminants of potential concern were (1) below universal treatment standards for F032 wastewater as outlined in Title 40 CFR Part 268.40, and (2) below Circular DEQ-7 criteria: Montana Numeric Water Quality Standards (DEQ-7) (DEQ 2006b) standards. The sampling also demonstrated that the treated IDW water was not a hazardous waste since (1) PCP was not present at a concentration greater than 1 microgram per liter ( $\mu\text{g/L}$ ), and (2) the concentrations of all parameters were below the TCLP maximum concentration listed in Table 1 of 40 CFR 261.24. After the IDW water samples were analyzed and results received, treated water that met state standards was land applied.

**Deviations from the RIWP.** The following deviations from the RIWP are noted for IDW.

- Segregated soil cuttings and other solid matrix IDW designated as RCRA hazardous waste were not subsequently transferred to roll-off bins because receiving facilities did not require this transfer.
- Composite samples of treated IDW water were proposed to be collected for every 500 gallons of treated water based on the expected size of the treatment tanks. However, larger tanks were procured for the treatment system, which allowed treatment of larger batches of water and reduced the number of confirmation samples required.
- Treated IDW water samples were planned to be analyzed for the following parameters: PCP, VOCs, SVOCs (including PAHs), dioxins and furans, chlorinated and nonchlorinated pesticides, chlorinated herbicides, pH, flash point, and metals. DEQ modified the analytical suite, however, to include only PCP, SVOCs (including PAHs), dioxins and furans, and EPH to be consistent with previous sampling of treated IDW water at the site.
- Treated IDW water was planned to be land applied in an uncontaminated area of the site. Per DEQ direction, treated IDW water was sprayed within the fenced area at the Reliance facility.

### **3.0 PHYSICAL CHARACTERISTICS AND ENVIRONMENTAL SETTING**

This section includes a summary of the physical characteristics and environmental setting in the vicinity of and at the KRY Site including climate, ecology, soils, geology, surface water hydrology, hydrogeology, and LNAPL contamination found in groundwater at the site.

#### **3.1 CLIMATE**

A weather station is present at the Kalispell Regional Airport (weather station 244558), 8 miles north of Kalispell. However, data from this weather station were not used because they are not representative of conditions in the city (U.S. Department of Agriculture [USDA] 1960). Climate information considered representative of conditions at the KRY Site was obtained from the Western Regional Climate Center (WRCC 2005) for weather station number 244563, located in the City of Kalispell.

The climate of Kalispell is typical for the Northern Rocky Mountain region. The wettest months are May and June; most of the winter precipitation falls in December and January, primarily as snowfall. Kalispell's climate is considered semiarid, with an average 15.15 inches of precipitation per year and an average temperature of 44.4 °F. The climate records extend from the year 1948 to 2005. In the 57-year period of record, the maximum amount of precipitation in one year was 20.29 inches in 1959; the minimum amount of precipitation in 1 year was 8.79 inches in 1952. The average maximum monthly temperature of 81.9 °F was reported for July, and the average minimum monthly temperature of 14.4 °F was reported in January (WRRC 2005).

#### **3.2 ECOLOGY**

The scattered and intermixed areas of forest, grass, cultivated fields, and water of the Upper Flathead Valley Area provide good food and cover for all kinds of wildlife, and lakes and rivers are considered excellent habitat for shore birds, blackbirds, and herons. Canada geese nest along the Flathead and Stillwater Rivers, and streams and marshes provide excellent habitat for beaver and muskrat. Trout is the principal fish species; pheasants and Hungarian partridge are the main upland game birds, and the white-tailed deer is the main big game animal of the valley. Other common mammals include skunks, cottontail and snowshoe rabbits, ground squirrels, and pocket gophers (USDA 1960). Although historic USGS maps of the Kalispell region indicate the presence of a "Stillwater Wildlife Preserve," the Montana Department of Fish Wildlife and Parks no longer has record of a preserve in their database (TTEMI 2005).

The Montana Natural Heritage Program has identified four animal species of concern in the vicinity of the KRY Site (2005); there were no plant species of concern. Animal species of concern include the bald eagle (*Haliaeetus leucocephalus*), westslope cutthroat trout (*Oncorhynchus clarki lewisi*), bull trout (*Salvelinus confluentus*), and lynx (*Lynx canadensis*). None of these species were observed at the KRY Site during the RI field investigation.

### 3.3 SOILS

The soil types found at the KPT, Reliance, and Yale Oil facilities are dominated by material that has been deposited by the nearby Stillwater River or that was deposited by glaciers and reworked by fluvial processes. Soil types found at each facility are described below.

#### **KPT Facility**

Four main soil mapping units are found at the KPT facility and are described in more detail in the soil survey completed for the Flathead Valley (USDA 1960). The soil mapping units include the following:

- **Aa: Alluvial land, poorly drained.** This land type characteristically has poor surface and internal drainage. Surface soils are generally darker, the subsoil is typically mottled, and the surface soil and upper subsoil layers are more loamy and silty. The surface soil is sandy and light colored in areas adjacent to stream channels. The land type occupies nearly level areas, slight depressions, seepy spots next to higher land in the broad floodplains, and poorly drained narrow valleys where stream channels are not well defined. The land is subject to flooding.
- **Ba: Banks loamy fine sand, 0 to 4 percent slopes.** Banks soils are sandy soils that occupy floodplains and are subject to frequent flooding. They are developed in recently deposited, very sandy alluvium.
- **Bc: Birch fine sandy loam, 0 to 5 percent slopes.** Birch soils are shallow, light-colored sandy soils found on high terraces and low bottoms. They are underlain by loose, gravelly sand at depths ranging from 10 to 24 inches. These soils have been developed from alluvium that washed from mountains and from older high terraces where larger streams are now entrenched. The alluvium was derived from quartzite, argillite, dolomite, and limestone. The soil is low in organic matter and well drained.
- **Rc: Riverwash.** Riverwash is fresh alluvium not yet developed into a soil. This mapping unit consists of areas of light-colored, alluvial sand mixed with a small amount of gravel. Some of the areas in sharp river bends are mainly gravel and a little coarse sand.

## **Reliance Facility**

Only one soil unit has been identified for the Reliance facility:

- So: Swims silt loam, 0 to 3 percent slopes. Swims soils consists of deep, light-colored silty soils. These soils have developed in deep, light-colored, medium-textured, calcareous alluvium on high bottom lands and low terraces. The parent material was derived from argillite, quartzite, and dolomitic limestone, all of the Belt Supergroup geological formation. The soils have been reworked from glacial drift.

## **Yale Oil Facility**

One soil unit has been identified for the Yale Oil facility:

- Mg: Mires gravelly loam, 0 to 3 percent slopes. Mires soils consists of moderately deep, medium-textured soils with a gravelly, coarse-textured lower soil and substratum. The soils have developed in calcareous outwash and terrace alluvium. The parent materials were deposited by swift waters during the retreat of the glaciers from the valley and adjacent mountain slopes. The soils are well drained.

## **3.4 GEOLOGY**

The regional and local geology of the Kalispell Valley are described in the following sections.

### **3.4.1 Regional Geology**

The Kalispell Valley is a north-northwest trending intermontane basin located within the southern extension of the thousand-mile-long Rocky Mountain Trench (Harrison and others 1992). The trench was formed in the late Paleocene to Eocene. Normal faults are found along the eastern and western sides of the Kalispell Valley and numerous faults cross-cut the basin, contributing to its irregular shape (Kendy and Tresch 1996). The down-dropped crustal block (graben) that occupies the Kalispell Valley contains 4,000 feet of Cenozoic basin fill deposits at its deepest point (Noble and others 1982, Harrison and others 1992).

Bedrock in the area consists of Middle Proterozoic Belt Supergroup metasediments that surround the Kalispell Valley. The metasediments include argillite, siltite, quartzite, dolomite, and limestone (Harrison and others 1992).

Tertiary sediments do not crop out in the Kalispell Valley (Konizeski and others 1968). However, like other basins in the Rocky Mountain Trench, a thick sequence of Tertiary sediments exists in the basin and is overlain by glacial and alluvial sedimentary units (Harrison and others 1992). A deep oil exploration well drilled in 1984 just north of Kalispell (near Whitefish) encountered the Belt Supergroup Helena Formation at a depth of 1,695 feet. Tertiary sediments, including lignite, clay, and argillaceous, sandy siltstone, overlie the Helena Formation from 1,695 feet to 1,120 feet bgs. Peat, clay, and some sand were found from 1,120 feet to 600 feet bgs. Quaternary (Pleistocene) glacial deposits overlie the Tertiary sediments from 600 feet bgs to the surface (Kendy and Tresch 1996).

Based on a Cenozoic basin fill isopach map prepared for the Kalispell Valley, 600 to 1,000 feet of Quaternary glacial deposits and alluvial sediments overlie the Tertiary deposits (Noble and Stanford 1986). The base of the Quaternary deposits consists of glacial outwash deposits that are well-sorted, poorly bedded sand, gravel, cobbles, and boulders. The glacial outwash deposits are interbedded with and underlie discontinuous lenses of fine-grained glacial till and glacial lakebed deposits (Kendy and Tresch 1996). The north-central and western parts of the Kalispell Valley are underlain mostly by till that formed moraines and drumlins and by glacial outwash that is overlain by a thin mantle of glaciolacustrine silt and sand (Konizeski and others 1968). The east and central valley terraces are underlain mostly by till and kame deposits of well-rounded, well- to poorly sorted stratified gravel and cobbles. Kame deposits more than 100 feet thick are exposed in gravel pits within the city limits of Kalispell. The till and kame deposits are overlain by a thin mantle of glaciolacustrine silt and sand (Konizeski and others 1968).

Holocene (Recent) floodplain alluvium is typically material reworked from the glacial drift and deposited in a wide range of fluvial and alluvial environments. The northern end of the Kalispell Valley is dominated by well-sorted, interbedded gravel and sand; the southern end of the valley is primarily silt and sand (Konizeski and others 1968). A geologic map for the area near the KRY Site is shown in Figure 3-1.

### **3.4.2 Local Geology**

The KPT, Reliance, and Yale Oil facilities are located adjacent to or in proximity to the Stillwater River, just north of Kalispell, at an elevation of 2,920 feet above mean sea level (ThermoRetec Consulting Corporation [ThermoRetec] 2001). The area in the vicinity of the KRY Site is a relatively flat, broad floodplain that is composed of Quaternary age materials ranging from clay- to cobble-sized materials. These deposits are characteristic of a high-energy system with occasional quiescent periods (EPA 1992). Boreholes drilled as part of previous investigations extended to a maximum depth of 135 feet bgs (RETEC 1995). Deep boreholes (B wells) drilled during this RI extended to depths of 70 to 243 feet bgs.

Previous investigations (ThermoRetec 2001) indicated that the upper 30 feet is a mix of interbedded and intermixed sand and gravel with some cobbles, silty sand, and clay. Silty sand primarily underlies the upper material and extends to a depth below 100 feet. Lithologic data obtained during this RI were used in conjunction with previous information obtained during drilling to construct additional geologic cross sections, which are described in Section 3.6.1.

### **3.5 SURFACE WATER HYDROLOGY**

Regional surface water resources of the Kalispell Valley have been previously investigated by the U.S. Geological Survey (USGS 1996) and others; a summary of available regional information is provided below. Previously published site-specific information related to surface water hydrology for the KRY Site is also summarized in the following sections.

#### **3.5.1 Summary of Regional Surface Water Resources**

In general, the southwestward-flowing Flathead River is the principal surface water flow in the Kalispell Valley. Major tributaries include the Whitefish, Stillwater, and Swan Rivers. The Whitefish River flows southward from Whitefish Lake at a gradient of about 2 feet per mile to its confluence with the Stillwater River on the northeastern outskirts of Kalispell. The Stillwater River enters the basin from the northwest and flows south-southeastward at a gradient of about 2 feet per mile to its confluence with the Flathead River, about a mile southeast of Kalispell. The Flathead River enters the basin from the east near Columbia Falls and flows south-southwestward toward Kalispell at an average gradient of about 6 feet per mile.

About one-third of the flow of the Flathead River (that is, the contribution from the South Fork of the Flathead River) has been regulated by Hungry Horse Reservoir since 1951. Below Kalispell, the Flathead River meanders across its delta to Flathead Lake at a reduced gradient of about 1 foot per mile. The Swan River enters the southeastern corner of and then traverses the basin for about 8 miles before it empties into Flathead Lake. Sixteen tributary streams enter the Kalispell Valley from the mountains; however, most of the streamflow either infiltrates directly into basin fill or is diverted for irrigation (Konizeski and others 1968).

The Kalispell Valley contains more than 40 lakes. Flathead Lake, with an area of 126,000 acres, is the largest natural freshwater lake in the western United States (MDHES 1994). Its natural storage capacity is increased by Kerr Dam, which was constructed in 1938.

Streamflow data are available for five gauging stations in the Kalispell area and are either stored in the USGS WATSTORE database or have been published in water-supply papers and annual water-data reports issued annually by the USGS (various years). The five gauging stations include two stations on the Flathead River near Columbia Falls and Kalispell, one station on the Stillwater River near Kalispell, one station on the Whitefish River near Kalispell, and one location on Ashley Creek near Kalispell. Flow statistics for these five stations are presented in Table 3-1.

### **3.5.2 Summary of Local Surface Water Hydrology**

The KPT, Reliance, and Yale Oil facilities are all located in proximity to and south and west of the Stillwater River (Figure 1-1). The river generally flows from west to east. There are currently no nearby operational stream gauging stations (USGS 1996). Based on mapping information provided by the Federal Emergency Management Agency (FEMA), it appears that the majority of the KRY Site is situated outside of the 100- and 500-year floodplains, except for a small area on the west side of the KPT facility, and a small area near the railroad tracks on the northeastern edge of the Reliance facility (Flathead County 2005). However, the scale of the FEMA maps does not lend itself to predicting the exact boundaries of the floodplains on a property-specific basis with a high degree of accuracy. The RI investigation confirmed (see Section 3.6.5) that surface water and groundwater in the unconfined aquifer are generally interconnected (MSE 1989), with the Stillwater River likely discharging to the upper aquifer in the vicinity of the KRY Site (EPA 1992; ThermoRetec 2001). Limited surface water quality sampling for the Stillwater River just above the confluence with the Whitefish River was conducted by the Flathead Lake Biological Station (University of Montana) in 1995 and 1996.

Montana rivers and streams are classified according to the present and future beneficial uses they normally would be capable of supporting (Montana Code Annotated §75-5-301). The Board of Environmental Review (BER) adopts rules that classify the Stillwater River mainstem from Logan Creek to the Flathead River as “B-2” (Administrative Rules of Montana 17.30.608). BER classifies the Whitefish River from the outlet of Whitefish Lake to the Stillwater River as B-2. BER classifies the Flathead River above Flathead Lake as B-1. These classifications indicate that waters should be suitable for drinking, culinary use, and food processing after conventional treatment; bathing, swimming, and recreation; growth and marginal propagation of salmonid fishes and associated aquatic life, waterfowl and furbearers; and agricultural and industrial water supply.

## 3.6 HYDROGEOLOGY

This section includes descriptions of site hydrogeology including site stratigraphy and hydrogeology, RI field measurements, groundwater gradients and flow direction, aquifer testing results, and groundwater-surface water interaction.

### 3.6.1 Site Stratigraphy and Hydrogeology

Lithologic materials at the KRY Site consist of a mixture of fine- to coarse grained alluvial materials ranging in size from clay to cobbles. The dominant lithology at the site is sandy silty gravel and gravelly silty sand. Also present are intervals of clay, silt, silty fine- to medium-grained sand, and fine- to coarse-grained sand. Cobbles are present through out the site within various lithologies but are generally found within the sandy gravel and gravelly sand. Borehole logs for RI monitoring wells and soil borings are provided in Appendix D.

Three distinctive hydrostratigraphic units are present at the KRY Site. From the ground surface downward, these units can be described as:

1. An unconfined aquifer composed of unconsolidated alluvium with discontinuous lenses of clays and/or silts,
2. A low-permeability confining unit composed of clayey gravelly silt and silty clay at the base of the unconfined aquifer, and
3. A confined aquifer system composed of unconsolidated alluvium underlying the low-permeability unit. Drilling during this RI or previous investigations did not penetrate the top of the confined aquifer; this hydrostratigraphic unit will therefore not be discussed further.

Four geologic cross sections were developed from borehole drilling data. Figure 3-2 shows the location of cross sections A-A', B-B', C-C', and D-D'. Groundwater at the site generally flows from west to east. Cross sections A-A' and B-B' generally parallel groundwater flow, and cross sections C-C' and D-D' are located approximately transverse to groundwater flow. The cross sections illustrate (1) site lithologies within the unconfined aquifer system, (2) a snapshot of August 2006 static water levels, (3) vertical gradients for groundwater measured at paired (shallow and deep) wells, (4) the saturated thickness of the aquifer, (5) monitoring well completions, and (6) the elevation and slope of the underlying clayey silt low-permeability unit.

Site stratigraphy along cross section A-A', which runs west to east along the south portion of the project area, is shown on Figure 3-3. The lithology along the western portion of this section is generally sandy gravel and gravelly sand with interbedded silt, silty sand, and sand. The eastern portion of this section is sandy gravel transitioning to primarily silt, clay, and sand east of monitoring well KRY121B. A clay interval is present near the surface in monitoring wells KRY121B and GWY-3 and extends to monitoring well KRY129B. The saturated thickness of the unconfined aquifer along this location varies from approximately 80 feet at monitoring well KRY102B to approximately 115 feet at monitoring well KRY129B. Depth to groundwater along this section was 15 to 20 feet bgs with the exception of the easternmost portion of the KRY Site, where groundwater was less than 10 feet bgs at monitoring wells NTL-MW-3 and NTL-MW-4.

The low-permeability confining unit of clayey silt at monitoring well KRY121B was first encountered at 125 feet bgs and was still present at 243 feet bgs, where drilling was terminated (see KRY121B drill log in Appendix D). A deep monitoring well was originally planned to be drilled into the underlying confined aquifer at this location. However, the thickness of the low-permeability confining unit made drilling difficult, and installation of the planned deep well was cancelled. The minimum thickness of the clayey gravelly silt low-permeability confining unit at this location is 119 feet. All monitoring wells drilled into the lower portion of the unconfined aquifer as part of this RI encountered the very upper portion of this low-permeability confining unit. The unit is characterized as a clayey gravelly silt and/or a silty sandy clay. This unit was generally yellowish brown with red and green mottling resulting from weathering of red and green argillite and siltite gravels imbedded in a silty clay matrix. The percentage of gravel in this clay silt unit was generally about 10 to 15 percent, and the materials were stiff and dry just below the initial contact. The unit is generally non-plastic to slightly plastic, depending on the amount of clay present.

Site stratigraphy along cross section B-B', which runs west to east along the center of the project area, is shown on Figure 3-4. The lithology along this cross section is generally sandy gravel with intervals of silty sand and sand. A near surface 15- to 20-foot-thick clay interval is present in monitoring wells KRY136A and KRY137A. East of monitoring well KRY130A, sandy gravel transitions to primarily fine-grained deposits of silt and clay at monitoring well KRY139B. Section B-B' shows the clayey silt low-permeability confining unit contact dropping more than 110 feet in elevation from west to east. The saturated thickness of the unconfined aquifer along this location varies from approximately 80 feet at well KRY101B to approximately 175 feet at well KRY139B.

Site stratigraphy along cross section C-C' is shown in Figure 3-5. Cross section C-C' represents the subsurface along a south-to-north line located on the east side of the project area and traverses through the Reliance facility. Fine-grained sand is the dominant lithology at the southernmost portion of this section at monitoring well KRY122A. This sand transitions to sandy gravel northward. North of monitoring well KRY121B, a 15- to 30-foot-thick clay body is present 10 feet bgs at monitoring well locations KRY138A, KRY135A, KPT18, and KRY119A. This clay body is also present at the north side of the Reliance facility in monitoring wells KRY117A, KRY119A, and KRY123A. This extensive clay body throughout the Reliance facility appears responsible for apparent water level mounding and complicated horizontal groundwater flow. These topics will be described in more detail in Section 3.6.3.

The saturated thickness of the unconfined aquifer along section C-C' ranges from 75 feet at monitoring well KRY122B to 105 feet at monitoring well KRY121B. A slight depression or trough in the clayey silt low-permeability confining unit surface can be observed at location monitoring well KRY121B and may indicate a paleochannel or historical erosion surface cut into the top of the low-permeability confining unit.

Cross Section D-D', shown in Figure 3-6, illustrates site stratigraphy along a south-to-north line near the center of the project area. The geology at the southernmost portion of this section at monitoring well KRY116B is primarily silty fine-grained sand and silt with small lenses of sandy gravel near the base of the unconfined aquifer. Traversing northward, the silty sand continues along the bottom half of the unconfined aquifer. The silty sand in the upper half of the aquifer north of monitoring well KRY112B changes to sandy gravel above a laterally extensive 30-foot-thick sand body. This sand body interfingers with a 75-foot-thick clay unit at monitoring well KRY110B. The vertically extensive clay unit at monitoring well KRY110B appears to be localized and is not continuous with the clay units located at the Reliance facility.

A cut in the surface of the clayey silt low-permeability confining unit is found at monitoring well KRY111B. This trough is just west of the smaller trough observed at monitoring well KRY121B (see cross section C-C') and may also be associated with a paleochannel or historical erosion surface. The maximum saturated thickness of the aquifer observed on section D-D' is 115 feet at location KRY111B.

Lithologic data from borehole logs indicate that the western portion of the site in the vicinity of monitoring wells KRY102B, KRY113B, and KRY106B is dominated by sandy gravel and gravelly sand. Numerous lenses of sand are present within this laterally extensive sand and gravel. These sand bodies

are generally less than 5 feet thick. In general, the western portion of the unconfined aquifer contains limited amounts of silt and clay. However, clay lenses were present at monitoring well KRY103B.

### **3.6.2 Field Measurements**

Water quality parameters were recorded from purge water before groundwater was sampled at each monitoring well. The field parameters measured included temperature, DO, ORP, pH, specific conductance (SC), and turbidity. Field measurements were collected when monitoring wells were purged until measurements of temperature, conductivity, DO and pH stabilized. Groundwater samples were collected after parameters had stabilized. Field measurements are shown in Table 3-2.

### **3.6.3 Groundwater Gradients and Flow Direction**

Groundwater levels are measured monthly at the KRY Site by DEQ. Groundwater was measured on July 11 and 12, 2006, by TtEMI, August 1<sup>st</sup> through 3<sup>rd</sup>, 2006, September 5<sup>th</sup> through 7<sup>th</sup>, 2006, and October 3<sup>rd</sup> through 5<sup>th</sup>, 2006, by DEQ (DEQ continues to collect monthly groundwater measurements). The August and October water level measurements were evaluated as part of this RI for the hydrogeologic assessment. All groundwater level data collected from July through October 2006 are found on Table 3-3. As shown on Table 3-3, site-wide water levels generally dropped from July through September, and then rose in October.

Groundwater level measurements collected in August indicate that groundwater flow is generally from west to east in both the upper and lower portions of the unconfined aquifer (Figures 3-7A and 3-8). The overall site-wide horizontal groundwater gradient is approximately 0.0057 feet/foot in the upper portion of the unconfined aquifer. The horizontal groundwater gradient in the lower portion of the unconfined aquifer is approximately 0.0055 feet/foot. The groundwater elevation decreases from west to east approximately 19.5 feet over a distance of 3,500 feet (between upgradient well KRY103A and downgradient well KRY139A) in both portions of the unconfined aquifer. Localized areas within the project site show both shallower horizontal gradients (in the central portion of the KPT facility and at the eastern end of the McElroy and Wilken gravel pit) and steeper horizontal gradients (at the Reliance and Yale Oil facilities, and Town Pump property). Localized changes in horizontal gradients are likely as a result of changes in site lithologies and aquifer permeabilities.

Although the lower portion of the unconfined aquifer shows a relatively constant gradient from west to east, two areas of apparent groundwater mounding are identified in the upper portion of the unconfined aquifer. One area of groundwater mounding is centered around monitoring wells KRY137A and

KRY135A on the Reliance facility. Another area of groundwater mounding is present near monitoring wells GWY-3, KRY125A, and KRY129A, located in the vicinity of the Office Max, Rocky Mountain Marine, and Town Pump properties. The two groundwater mounds show steeper gradients and varying directions of groundwater flow in these areas of the upper portion of the unconfined aquifer.

Groundwater in the mounded areas moves radially away from the centers of the mounds. Groundwater which flows radially off the mounds eventually returns to the shallow groundwater flow system which generally flows from west to east. These mounds are shown on Figure 3-7A. For comparison, October 2006 potentiometric conditions are presented on Figure 3-7B.

The groundwater mounding appears to be associated with areas where shallow monitoring wells are completed in finer-grained materials dominated by silt, silty clay, or clay. Groundwater measurements indicate a decrease in water levels from July to August in monitoring wells completed in coarser-grained materials such as sand and gravel. Water levels in monitoring wells completed in these materials decreased approximately 1 to 1½ feet between the July and August measurements. In contrast, groundwater levels in monitoring wells completed in silts and silty clays decreased less than ½ foot. The vertical movement of groundwater is likely impeded by the less permeable materials. The occurrence of groundwater mounding at the Reliance facility and in the vicinity of the Town Pump property was also identified in previous investigations (Spratt and Associates 1992; Pioneer 2000).

Water levels in 20 locations with paired shallow and deep monitoring wells were used to calculate vertical hydraulic gradients. Twelve of the paired monitoring well locations showed downward vertical gradients, while eight paired monitoring well locations showed upward vertical gradients (Table 3-4). Differences in elevation for well pairs with downward gradients ranged from 0.09 feet at monitoring wells KRY122A and KRY122B to 8.4 feet at monitoring wells KRY125A and KRY125B and 10.15 feet at monitoring wells KRY129A and KRY129B. (The reason for the large vertical gradients between the well pairs at KRY125 and KRY129 is not known. Well completion in the varying geology may be responsible for the observed gradient. Further monitoring data may provide additional insight). Differences in elevation for locations with upward vertical gradients ranged from 0.03 feet at monitoring wells KRY102A and KRY102B to 0.56 feet at monitoring wells KRY111A and KRY111B. Based on these water level measurements and vertical gradient calculations, there does not appear to be a predominant vertical gradient direction at the KRY Site.

### 3.6.4 Aquifer Testing Results

Aquifer pumping tests were conducted in six monitoring wells from August 16 through August 22, 2006. Drawdown and recovery data were collected using Mini-Troll down-hole pressure transducers and data loggers. Data were downloaded directly to an on-site laptop computer using Win-Situ Version 4.5 Instrument Control Software (In-Situ 2006). Aquifer test data were analyzed using AQTESOLV Version 4.01 Professional for Windows (HydroSOLVE, Inc. 2006) software. This software was used to calculate aquifer transmissivity using test methods developed by Theis (1935) and Cooper Jacob (1946). Aquifer hydraulic conductivity was estimated using the calculated transmissivity and observed aquifer saturated thickness evidenced during monitoring well drilling. Aquifer hydraulic conductivity was obtained using the following equation:

$$T=kb$$

where

T = Transmissivity

k = hydraulic conductivity

b = aquifer saturated thickness (Fetter 1980)

A summary of aquifer pumping tests and resulting transmissivities and calculated hydraulic conductivities is provided in Table 3-5. Graphical analytical plots of the analyses and tabulated water level drawdown and recovery data are included in Appendix I. Aquifer pumping tests completed at each well are described below.

#### **Well KRY108A**

An aquifer pumping test was conducted at shallow monitoring well KRY108A (2-inch diameter) after attempts to pump and maintain a sustained discharge at monitoring well KRY113A (4-inch diameter) failed.

Monitoring well KRY108A is 32 feet deep and is screened in the upper portion of the unconfined aquifer. The 2-inch submersible pump was set at approximately 28 feet bgs for the test. A constant pumping discharge rate of 6.1 gpm was maintained for 94 minutes. Maximum detectable drawdown in the pumping well during this time was only 0.03 foot. A pressure transducer was placed in well KRY113A, located 50 feet north of well KRY108A. No drawdown was measured in observation well KRY113A during the test. Water level drawdown data collected during this test were evaluated but could not be

used for calculation of aquifer transmissivity because the test yielded insufficient drawdown to complete the analysis.

### **Well KRY 113A**

An aquifer pumping test at location KRY113A could not be completed because the water level drew down rapidly to the top of the pump at a pumping rate of 1.5 gpm. The cause of this anomalous drawdown was uncertain. Well KRY113A appeared to be inefficient and was considered not to represent local aquifer conditions. Consequently, a shallow well aquifer test was conducted at location KRY108A, which is located close (within 75 feet) to well KRY113B.

### **Well KRY 113B**

Monitoring well KRY113B is 117 feet deep, is 2 inches in diameter, and is screened in the lower portion of the unconfined aquifer. The submersible pump was set at approximately 50 feet bgs for the test. A constant discharge rate of 6.1 gpm was maintained for 112 minutes, and the maximum observed drawdown in the well was 1.1 feet. Water level measurements were also recorded with a pressure transducer in adjacent shallow well KRY113A. Drawdown was not detected at well KRY113A during the test.

The calculated aquifer transmissivity at well KRY113B is 5,500 feet squared per day ( $\text{ft}^2/\text{day}$ ) using the Theis unconfined aquifer solution method (Theis 1935). Based on a saturated aquifer thickness of 91 feet, the calculated hydraulic conductivity of the aquifer at this location is 60 feet per day ( $\text{ft}/\text{day}$ ). Recovery data could not be analyzed because of instantaneous recovery of the water level in pumping well KRY113B after the pump was shut down.

### **Well KRY121A**

Monitoring well KRY121A is 32.5 feet deep, is 2 inches in diameter, and is screened in the upper portion of the unconfined aquifer. The submersible pump was set at approximately 30 feet bgs for the test. A constant discharge rate of 6.1 gpm was maintained for 56 minutes, and the maximum drawdown observed was only 0.1 foot. Water levels were also recorded at nearby monitoring well GWRR-8, located 260 feet northwest of monitoring well KRY121A. Drawdown was not observed in monitoring well GWRR-8 during the test. Water level drawdown data collected during this test were evaluated but could not be used for calculation of aquifer transmissivity because the test yielded insufficient drawdown to complete the analysis.

### **Well KRY121B**

Monitoring well KRY121B is 134 feet deep, is 4 inches in diameter, and is screened in the lower portion of the unconfined aquifer. The submersible pump was set at approximately 50 feet bgs for the test. A constant discharge rate of 30 gpm was maintained for 42 minutes with a maximum drawdown of 1.1 feet. A pressure transducer was installed in adjacent shallow monitoring well KRY121A to monitor drawdown. A drawdown of 0.01 foot was measured at monitoring well KRY121A.

The transmissivity for the lower portion of the unconfined aquifer at this location was estimated at 24,610 ft<sup>2</sup>/day using the Theis unconfined aquifer solution method (Theis 1935). Based on a saturated aquifer thickness of 106 feet, the estimated hydraulic conductivity is 326 ft/day.

### **Well KRY139A**

Monitoring well KRY139A is 29 feet deep, is 4 inches in diameter, and is screened in the upper portion of the unconfined aquifer. The submersible pump was set at approximately 27 feet bgs for the test; a constant discharge rate of only 5.8 gpm could be maintained. The well was pumped for 105 minutes. The maximum observed drawdown in pumping well KRY139A was 2.97 feet. A pressure transducer was placed in adjacent deep monitoring well KRY139B; however, drawdown was not observed at this monitoring well during the test. Recovery data were collected for 15 minutes after the pump was shut down.

The calculated transmissivity for monitoring well KRY139A is 2,800 ft<sup>2</sup>/day using the Theis unconfined aquifer solution method (Theis 1935). Based on a saturated aquifer thickness of 164 feet, the estimated hydraulic conductivity for the upper portion of the unconfined aquifer in this area using the pumping test transmissivity value is 17 ft/day. Calculation of transmissivity and hydraulic conductivity for the recovery data used the length of the saturated portion of the well screen which was 14.6 feet. Analysis of the recovery data using the Theis confined solution produced a calculated transmissivity of 139 ft<sup>2</sup>/day and a hydraulic conductivity of 9 ft/day.

### **Well KRY139B**

Monitoring well KRY139B is 181 feet deep, is 2 inches in diameter, and is screened in the lower portion of the unconfined aquifer. The submersible pump was set at approximately 50 feet bgs during the test. A constant discharge rate of 6.1 gpm was maintained for 84 minutes. The maximum observed drawdown at pumping well KRY139B was 1.3 feet. A pressure transducer was placed in adjacent shallow monitoring

well KRY139A to monitor drawdown during the pumping test. There was no detectable drawdown in monitoring well KRY139A.

The calculated transmissivity for the lower portion of the unconfined aquifer at this location is 8,941 ft<sup>2</sup>/day using the Theis unconfined aquifer solution method (Theis 1935). Based on a saturated aquifer thickness of 164 feet, the estimated hydraulic conductivity of the lower portion of the unconfined aquifer at monitoring well KRY139B is 4 ft/day.

### **Summary of Aquifer Tests**

Data collected from aquifer tests completed as part of this RI are reasonable based on observed site lithologies and are consistent with results from previous aquifer tests which are discussed later in this section. The RI data can be used to estimate the hydrogeologic properties of the aquifer in the vicinity of the pumping tests. However, the aquifer test data are limited since they were acquired from very short-duration and low-volume pumping tests.

The low discharge rates were a result of the size of the pump that could be used in the 2-inch and 4-inch diameter wells. The maximum discharge rate that could be achieved for the 2-inch wells was approximately 6 gpm, and the maximum discharge rate for the 4-inch wells was approximately 30 gpm. The tests were of short duration because all discharge water needed to be contained, transported to the on-site ozone treatment system, stored, and subsequently treated. The storage capacity of the storage and treatment system limited the maximum volume of water that could be pumped during the six tests. The cost for additional storage tanks and/or tanker trucks and potential technical difficulties associated with storage and transportation of large volumes of water from longer tests was considered to out weigh the potential benefits of longer tests. Nonetheless, the short term pumping tests stressed the aquifer better than slug testing, and good quality data were used to estimate aquifer properties.

The short-duration and low-volume pumping tests conducted during the RI minimally stressed the unconfined aquifer; therefore, the amount of drawdown was limited at pumping wells and was not measurable at observation wells. The majority of drawdown observed at each pumping well occurred within the first minute of the test, and early drawdown data were generally interpreted as depletion in casing storage.

Analysis of the pumping test data was limited to evaluating data over a very short time that occurred after casing storage was depleted and before drawdown stabilized as a result of the limited pumping rates.

However, the calculated hydraulic conductivities of 17 to 326 ft/day are consistent with observed site lithologies and published literature values for silty sand to clean sand (Freeze and Cherry 1979). The pumping tests also provided qualitative information that showed short-duration, aquifer-specific capacities and that very limited drawdown occurred at pumping rates of 6 to 30 gallons per minute.

Results from previous aquifer tests conducted by RETEC (1995) and Spratt and Associates (1992) are shown in Table 3-6. Hydraulic conductivities calculated by RETEC on KPT facility wells ranged from 34 to 48 ft/day based on the results from five rising heading slug tests. Data from investigations by Spratt and Associates showed hydraulic conductivities to range from 0.4 ft/day (well EH-3) to 322 ft/day (well MW-14 at the Yale Oil facility). The Spratt and Associates aquifer test investigations included four slug tests and three short term pumping tests. The pumping rate for the short term tests was 0.94 gpm; however, the length of these short tests was not reported.

Aquifer test results obtained during this RI and from previous investigations are similar. They indicate that hydraulic conductivities of the aquifer vary throughout the site and are representative of silty fine sand, clean sand, and gravelly sand lithologies. In general, higher hydraulic conductivities are observed west of Highway 2 on the Yale Oil and KPT facilities, and lower hydraulic conductivities are present in the vicinity of and east of Highway 2. Given the depositional history of this alluvial and fluvial environment, the more permeable units possibly represent sand and gravel cut and fill or paleochannel deposits, while lower permeable units may suggest finer-grained floodplain or overbank deposits. The west-to-east transition of coarse- to fine-grained materials in the unconfined aquifer and the variability of aquifer materials is illustrated in cross sections A-A' (Figure 3-3) and B-B' (Figure 3-4). This transition and the variability of site lithologies are consistent with the range of observed aquifer hydraulic conductivities.

The seepage velocity of groundwater movement was estimated using the equation:

$$V = KI/n_e$$

where

V	=	Velocity of groundwater
K	=	Hydraulic conductivity
I	=	Hydraulic gradient
$n_e$	=	Effective porosity (Fetter1980).

The estimated groundwater seepage velocity ranged from 0.39 ft/day to 7.4 ft/day using calculated hydraulic conductivity values ranging from 17 ft/day to 326 ft/day, an average horizontal gradient of 0.0057 ft/ft, and a literature estimate for effective porosity for silty sands of 0.25 (unitless) (Fetter 1980).

### **3.6.5 Groundwater-Surface Water Interaction**

Surface water levels in July and August 2006 at surface water sample locations KRY201, KRY202, and KRY203 were compared with groundwater levels in adjacent monitoring wells KRY100A, KRY105A, and KRY109A (the wells close to the surface water location). The surface water elevation was higher than the adjacent groundwater elevation at all three locations, indicating that during the period of measurement the river was recharging the shallow aquifer at these locations (Figure 3-7 and Table 3-7). Regions of groundwater to surface water recharge are likely present upgradient and/or downgradient of the KRY Site. However, additional studies would be necessary to locate such regions.

The seasonal pond in the McElroy and Wilken gravel pit may seep water from the pond to groundwater. The seepage may cause temporary groundwater mounding below the pond, but additional water elevation data would be needed to evaluate whether the pond seepage has any impact on groundwater. Cement trucks frequently disposed of rinse water in this pit during the RI field work. However, impacts to local groundwater levels were not observed during the RI.

## **3.7 LNAPL CONTAMINATION IN GROUNDWATER**

LNAPL was encountered in eight monitoring wells during the RI, not including product recovery wells that were previously installed at the Reliance facility. The distribution of LNAPL in August 2006 is shown on Figure 3-9. LNAPL measurements collected in July and August 2006 are presented in Table 3-8. Measurable LNAPL was found in monitoring wells GWRR5, GWRR7, GWRR9, KPT3, KRY114A, KRY135A, KRY136A, and KRY138A. In August 2006, LNAPL thickness ranged from 0.01 feet in monitoring well KRY138A to 0.94 feet in monitoring well KRY114A.

#### 4.0 NATURE AND EXTENT OF CONTAMINATION

This section describes the results of RI sampling at the KRY Site and the nature and extent of contamination found at the site. Media that were sampled during the RI include groundwater, surface soil, subsurface soil, surface water, and sediment. Where applicable, data collected outside of the RI, including historical data, are referenced and discussed. Data for groundwater, surface water, and sediment presented and discussed in this section are limited to data collected during the RI. Historical data for groundwater, surface water, and sediment may not represent current conditions because of the transient nature of contaminants in these media and because groundwater treatment at the KPT facility has likely altered groundwater conditions in recent years. Data for surface and subsurface soil collected during the RI and from other previous investigations are presented and discussed. It should be noted, however, that conditions of both surface and subsurface soil may have been altered since historical data were collected as a result of ongoing industrial activities at the sites, interim action, and natural fate and transport processes. If historical data collection locations are known to be altered, this is described in the text. Data summary tables for all analyses collected during the RI are provided in Appendix G.

The purpose of the investigation and general investigation objectives for the KRY Site as stated in the RI work plan (TtEMI 2006) are to:

- Investigate the nature and extent of suspected sources of contamination located at the KRY Site. This objective includes investigating (1) the source of the groundwater plumes of PCP, dioxins and furans, PAHs, and diesel-range petroleum hydrocarbons, and associated soil contamination in the KPT source area, (2) the source of groundwater and soil contamination, notably sludges, oily wastes, petroleum hydrocarbons, and lead in the Reliance source area, and (3) the source of petroleum hydrocarbons in soils in the Yale Oil source area. This investigation focused on delineating the lateral and vertical extent of soil contamination in these areas and the presence and extent of measurable (more than 0.1 foot thick) LNAPL.
- Investigate potential sources of contamination in the vicinity of Montana Mokko, Inc., Stillwater Forest Products, Inc., and Klingler Lumber Company, including leaking drums, uncontainerized waste, abandoned aboveground fuel storage tanks, and septic drainfields that may be associated with maintenance shops.
- Investigate the nature, extent, and migration of contamination throughout the KRY Site. This investigation focused on delineating the lateral and vertical extent of groundwater contamination downgradient of the suspected source areas, including groundwater contamination east of Highway 2. In addition, data collected from this investigation is being used to further assess characteristics of the aquifer, contamination in surface water and sediment, the interaction of surface water and groundwater, and the extent of any additional surface soil contamination at, or close to, the site. Lastly, samples have been collected to establish background concentrations of contaminants in both soil and groundwater.

- Collect data that support future characterization of the risks at the site. This investigation gathered data needed to evaluate risks to human health and the environment. The investigation characterized (from a risk analysis standpoint) contaminated media and has identified likely exposure pathways and receptors.
- Gather data needed to evaluate likely remedial alternatives. This investigation gathered data to support some likely remedial alternatives that can be identified at this time. These alternatives include soil excavation, on-site treatment, off-site disposal, in situ groundwater treatment, in situ soil treatment, and LNAPL recovery with off-site disposal. The alternatives will be thoroughly identified and evaluated in the FS.

### **Data Quality Summary**

Overall, data produced under the RI is of high quality with few qualified or unusable results. Of the 56,447 total field sample results collected, only 186 results (0.3 percent) were rejected so the number of valid field sample results is 56,261. The 186 undetected results were rejected because of poor MS/MSD and LCS recoveries for antimony, benzoic acid, tetraethyllead, and tin and a poor low-concentration calibration verification recovery for zinc. All rejected data are unusable and considered incomplete and do not meet project objectives. Some groundwater data were also qualified as estimated because of irregularities in the continuing calibration, laboratory duplicate, MS/MSD, LCS, surrogate, and internal standard results. Sample results were qualified as estimated because some positive results were above the sample quantitation limit (SQL), but less than the laboratory required reporting levels. Some positive furan results were not confirmed on a second column and were also qualified as estimated. Estimated analytical results are quantitatively unreliable, but are qualitatively acceptable and meet project objectives. Some groundwater data were qualified as nondetected because of laboratory and field QC blank contamination. Results for dioxins and furans with ion abundance ratios outside the method-specified limits were also qualified as nondetected. All data except rejected results are usable to meet project objectives with the assigned qualifications.

The following sections describe the contaminants of potential concern, results of the investigation by media, and data gaps identified during the RI.

#### **4.1 CONTAMINANTS OF POTENTIAL CONCERN**

Statistical summaries of analytes detected in solid and liquid matrix samples are presented in Tables 4-1 through 4-5. The full list of detected analytes, statistical results for groundwater samples collected during the RI, and identification of contaminants of potential concern (COPCs) are found in Table 4-1; the results for surface soil samples are found in Table 4-2; the results for subsurface soil samples are found in Table 4-3; the results for surface water samples are found in Table 4-4; and the results for sediment

samples are found in Table 4-5. These summary tables present the total number of samples, the number and percentage of samples with detected analytes, and the minimum and maximum detected concentrations of each analyte. In addition, background concentrations and technical and regulatory standards used as screening criteria are compared with the detected concentrations of analytes in Tables 4-1 through 4-5 to determine if an analyte is a COPC.

Concentrations of constituents in surface water and groundwater at the KRY Site are screened using state standards presented in DEQ-7 (DEQ 2006b). These standards involve aquatic life and human health and apply to surface water and groundwater. Human health standards may be equivalent to the federal maximum contaminant levels. Tap water preliminary remediation goals (PRG) from EPA Region 9 (EPA 2004) are used when state groundwater standards are not available. Concentrations of constituents in soils, sediments, and sludges are compared with soil values from EPA Region 9 PRGs (EPA 2004), SSLs (with a DAF of 10), and risk based screening levels (RBSL) from Montana's Tier 1 Risk-Based Corrective Action Guidance for Petroleum Releases (RBCA) guidance per DEQ's Voluntary Cleanup and Redevelopment Act (VCRA) guide (DEQ 2002). Non carcinogenic COPC concentrations are compared to 1/10 of the EPA Region 9 PRG in accordance with DEQ policy. Concentrations in sediment are compared with Washington State Department of Ecology Freshwater Sediment Quality Values (Washington State Department of Ecology 1997) as recommended by DEQ's VCRA guide. Additionally, concentrations of constituents in sludge samples are compared with RCRA TCLP regulatory limits for disposal purposes (Table 1 of 40 CFR 261.24).

The RI considered analytes COPCs if they exceeded screening levels or have no screening levels, were present in more than 5 percent of the samples at concentrations above laboratory detection limits, were present above background concentrations, and are not laboratory standards (and not found at the site) or essential nutrients. In total, 31 analytes are considered COPCs for groundwater, 39 analytes are considered COPCs for surface soil, and 46 analytes are considered COPCs for subsurface soil. In addition, one analyte is considered a COPCs for surface water and no analytes are considered COPCs for sediment. Analytes include individual compounds (such as PCP) and groups of compounds (such as C11-C22 aromatic hydrocarbons). A calculated toxicity equivalency quotient (TEQ) for compound 2,3,7,8-tetrachlordibenzo-p-dioxin (2,3,7,8-TCDD) has been established for each dioxin and furan analysis. Toxicity equivalency factors (TEF) established by the World Health Organization in 1998 (WHO 2006) are used for groundwater. TEFs established by the World Health Organization in 2005 are used for soil (WHO 2006).

Based on the identification of COPCs and comparison to screening criteria, specific COPCs were selected for further discussion and presentation in the RI report based on their frequency of detection and incidence above screening levels. Selected COPCs for groundwater include PCP, dioxins and furans, benzene, 1,2,4-trimethylbenzene, and C9-C10 aromatic hydrocarbons. COPCs for surface soil include PCP, dioxins and furans, benzo(a)pyrene, lead, and C11-C22 aromatic hydrocarbons. COPCs for subsurface soil include PCP, dioxins and furans, benzo(a)pyrene, lead, and C9-C18 aromatic hydrocarbons. Selected COPCs for surface water are dioxins and furans. No COPCs were selected for further discussion or presentation for sediment because no compounds exceeded screening criteria.

## **4.2 GROUNDWATER INVESTIGATION RESULTS**

Groundwater samples were collected in selected monitoring wells, residential wells, industrial wells, and public water supply wells at the KRY Site and nearby vicinity during the RI sampling event in July and August 2006. No contaminants were found in industrial, residential, or public water supply wells at concentrations exceeding EPA's maximum contaminant levels allowed under the Safe Drinking Water Act. Twenty-two chemicals were detected in groundwater monitoring well samples at concentrations above the screening criteria (DEQ human health standard, the DEQ RBSL, or the EPA Region 9 tap water PRG), as summarized in Table 4-1. Sixteen of these chemicals are considered COPCs since they were detected at a frequency of greater than 5 percent and exhibited maximum concentrations greater than background. Six additional chemicals or chemical groups are considered COPCs since they were detected at a frequency of greater than 5 percent, exhibited maximum concentrations greater than background, are not essential nutrients, and do not have screening criteria. Nine additional compounds are considered COPCs because they are possible products from the breakdown of PCP. The full list of groundwater COPCs is presented in Table 4-1. Groundwater sampling results for SVOCs (including PAHs), dioxins and furans, VOCs, petroleum hydrocarbons, metals, and other parameters are discussed in this section. Groundwater sampling results for selected COPCs (PCP, dioxins and furans, benzene, 1,2,4-trimethylbenzene, and C9-C10 aromatic hydrocarbons) are presented on Figures 4-1 through 4-5 and are discussed further in this section. Complete analytical results are provided in Appendix G.

### **4.2.1 Semi-Volatile Organic Compounds Results**

Four SVOCs (PCP, bis[2-ethylhexyl]phthalate, 2,4,6-trichlorophenol, and naphthalene) were detected in groundwater samples at maximum concentrations that exceeded screening criteria. Two of these compounds (PCP and naphthalene) are considered COPCs since they were detected in more than 5 percent of samples and exhibited maximum concentrations greater than background. Three other

compounds 1-methylnaphthalene, 2,6-dimethylnaphthalene, and phenanthrene are considered COPCs since they were detected in more than 5 percent of samples, exhibited maximum concentrations greater than background, and do not have screening criteria. Of these COPCs, naphthalene and phenanthrene are PAHs. In addition, DEQ has requested that PCP breakdown products including tetrachlorophenols, trichlorophenols, dichlorophenol, and chlorophenol be retained as COPCs and identified on Table 4-1 in order to evaluate PCP breakdown and various remedial alternatives. No SVOCs or PAHs were detected in upgradient (background) monitoring well KRY101A.. Results for PCP are discussed below.

### **Pentachlorophenol**

Pentachlorophenol was detected in samples from 27 monitoring wells located in the upper portion of the unconfined aquifer and four monitoring wells located in the lower portion of the unconfined aquifer with concentrations ranging from 0.036J  $\mu\text{g/L}$  to 16,300  $\mu\text{g/L}$ . (The “J” qualifier indicates that the result is estimated; other qualifiers in historical data that indicate a result is estimated include “E”, “B”, and “\*”). Results for PCP for the upper and lower portions of the unconfined aquifer are shown in Figure 4-1. The highest concentrations of PCP within the upper portion of the unconfined aquifer are located within and immediately downgradient of the KPT facility, suggesting that the KPT facility is the primary source area for PCP. Detectable concentrations of PCP are found approximately 1,500 feet northeast (RW-1) and 1,800 feet southeast (GWY-14) of the former treatment area on the KPT facility. Two residential wells (RW-1 and RW-12) located northeast of the KPT facility had detectable PCP concentrations, but below the screening criteria. Residential well RW-1 is relatively shallow and completed at a depth of 38 feet bgs. No well completion information was available for residential well RW-12. It may be possible that there is PCP in the deeper portion of the aquifer underlying the residential areas and with limited deep wells in the vicinity it is impossible to determine if there is a preferential flow pathway.

The highest concentration of PCP within the lower portion of the unconfined aquifer is located at monitoring well MW129B, approximately 2,000 feet southeast of the former treatment area on the KPT facility. A concentration of 40  $\mu\text{g/L}$  was detected at this location at a depth of 127 to 137 feet bgs. However, pentachlorophenol was not detected in the upper portion of the unconfined aquifer at this location (KRY129A).

PCP was detected in monitoring wells KPT-2, KPT-5, and KRY114A at concentrations of 16,300, 7.4, and 427  $\mu\text{g/L}$  respectively, during this investigation. Monitoring well KPT-2 is located upgradient of the KPT facility ozonation system, monitoring well KPT-5 is located near the ozonation system, and monitoring well KRY114A is located downgradient of the ozonation system. These results suggest that

the ozonation system may be reducing PCP concentrations near the locations of the ozone injection wells, but that PCP concentrations in groundwater rebound downgradient of the ozonation system due to PCP source material (LNAPL) located in that area. Results of these analyses are included in Appendix G.

#### **4.2.2 Dioxins and Furans Results**

Dioxins and furans (2,3,7,8-TCDD TEQ) were detected in all groundwater samples at maximum concentrations that exceeded the screening criteria. Dioxins and furans were detected in samples from 18 monitoring wells located in the upper portion of the unconfined aquifer and eight monitoring wells located in the lower portion of the unconfined aquifer. Calculated 2,3,7,8-TCDD TEQ values range from 2.99 picograms per liter (pg/L) to 1,397.75 pg/L. All 2,3,7,8-TCDD TEQ results were above DEQ-7 screening criteria of 2.0 pg/L. Background concentrations of 2,3,7,8-TCDD TEQ were measured in upgradient monitoring well KRY101A at 5.58 pg/L. TEQ results for 2,3,7,8-TCDD in the upper and lower portions of the unconfined aquifer are shown in Figure 4-2. The highest concentrations of 2,3,7,8-TCDD TEQ within the upper portion of the unconfined aquifer are located within and immediately downgradient of the KPT treatment area, indicating that the KPT facility is the primary source area for dioxins and furans in groundwater. The approximate extent of groundwater with elevated concentrations of dioxins and furans above background concentrations is identified on Figure 4-2.

#### **4.2.3 Volatile Organic Compounds Results**

Twelve VOCs were detected in groundwater samples at maximum concentrations that exceeded the screening criteria (Table 4-1). Seven of these compounds are considered COPCs since they were detected in more than 5 percent of samples and maximum concentrations were greater than background. These compounds are benzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, 4-isopropyltoluene, ethylbenzene, n-butylbenzene, and toluene. No other VOCs were detected in more than 5 percent of samples. No tetraethyllead was detected in groundwater samples. No VOCs were detected in upgradient (background) monitoring well KRY101A. Results for benzene and 1,2,4-trimethylbenzene are discussed below.

##### **Benzene**

Benzene was detected in samples from six monitoring wells in the upper portion of the unconfined aquifer with concentrations ranging from 0.435J µg/L to 646 µg/L. The screening criteria was exceeded in three of the six samples. Benzene results for the upper portion of the unconfined aquifer are shown in Figure 4-3. The highest concentration of benzene within the upper unconfined aquifer was detected in monitoring

well NTL-MW-4 (646 µg/L), installed during a Phase I environmental site assessment and not as part of this RI, and located in the southern portion of the Seaman Shelton site (near Northern Energy Propane), southwest of Wal-Mart. Benzene was also detected in one monitoring well located on the Reliance property, but at a concentration below the screening criteria. This suggests that the source of benzene in groundwater is primarily within the Seaman Shelton site. Benzene was not detected in groundwater samples from the lower portion of the unconfined aquifer.

### **1,2,4-Trimethylbenzene**

1,2,4-Trimethylbenzene was detected in samples from 19 monitoring wells located in the upper portion of the unconfined aquifer. The extent of 1,2,4-trimethylbenzene contamination is shown on Figure 4-4. Concentrations range from 0.23J µg/L to 1,090 µg/L. The highest concentrations of 1,2,4-trimethylbenzene was detected in monitoring well PW-1, located within the Seaman Shelton site (near Northern Energy Propane) west of Wal-Mart. Concentrations of 1,2,4-trimethylbenzene above screening criteria were also found in samples collected from monitoring wells located at Reliance, KPT, and immediately south of Yale Oil. 1,2,4-trimethylbenzene was not detected in groundwater samples from the lower portion of the unconfined aquifer.

### **4.2.4 Petroleum Hydrocarbons Results**

Four petroleum hydrocarbon groups (C5-C8 aliphatics, C11-C22 aromatics, C9-C10 aromatics, and C9-C12 aliphatics) were detected in groundwater samples at maximum concentrations that exceeded the screening criteria. These analytes are considered COPCs since they were detected in more than 5 percent of samples and maximum concentrations are greater than background. Two other hydrocarbon groups, total extractable hydrocarbons (TEH) and total purgeable hydrocarbons, are considered COPCs since they were detected in more than 5 percent of samples, exhibited maximum concentrations greater than background, and do not have screening criteria. TEH were detected in 15 of 28 samples and concentrations range from 220 µg/L (GWRM-2) to 3,500 µg/L (PW-1). No petroleum hydrocarbons were detected in upgradient (background) monitoring well KRY101A.. Results for C9-C10 aromatic hydrocarbons in groundwater are discussed below.

### **C9-C10 Aromatic Hydrocarbons**

C9-C10 aromatic hydrocarbons were detected in samples from 25 monitoring wells located in the upper portion of the unconfined aquifer. The extent of the C9-C10 aromatic hydrocarbon contamination is

shown on Figure 4-5. Contaminant concentrations range from 23 µg/L to 5,360 µg/L. Elevated concentrations of C9-C10 aromatic hydrocarbons are located throughout the KRY Site, with the highest concentrations found in groundwater samples collected within the Seaman Shelton site (near Northern Energy Propane), west of Wal-Mart. It appears that separate source areas are associated with the distribution of C9-C10 aromatic hydrocarbons in the upper portion of the unconfined aquifer. One source area is associated with the Seaman Shelton site (near Northern Energy Propane) which appears distinctly separate from other sources associated with KPT, Reliance, and Yale Oil facilities (Figure 4-5). Concentrations exceeding DEQ RBSLs were identified at each of the three facilities. C9-C10 aromatic hydrocarbons were not detected in groundwater samples from the lower portion of the unconfined aquifer.

#### **7.1.4 Metals Results**

Three metals (arsenic, iron, and manganese) were detected in groundwater samples at maximum concentrations that exceeded the screening criteria. These analytes are considered COPCs since they were detected in more than 5 percent of samples and maximum concentrations were greater than background. Detectable arsenic concentrations ranged from 6 µg/L (KRY114A) to 70 µg/L (KPT-2). Detectable iron concentrations ranged from 120 µg/L (GWY-10) to 18,990 µg/L (GWRR-7). Detectable manganese concentrations ranged from 19 µg/L (KPT-15) to 12,570 µg/L (GWRR-7). Iron and manganese were detected in groundwater samples from upgradient (background) well KRY101A. The background concentration of barium was 260 µg/L; iron was 230 µg/L; and manganese was 778 µg/L.

#### **4.2.6 Other Parameters Results**

Groundwater upgradient, and in the vicinity, of the existing ozonation system on the KPT facility was analyzed for indicator analytes and breakdown products of PCP in an effort to evaluate the effectiveness of the ozonation system in reducing the concentrations of PCP in groundwater. These samples were also collected to evaluate whether the existing ozonation system may currently be generating toxic byproducts. Chloride ions and PCP concentrations were used as indicator analytes as well as potentially toxic byproducts of the oxidation of PCP including aldehydes (specifically, formaldehyde), ketones (specifically, acetone), and bromate.

Groundwater from the upper portion of the unconfined aquifer was collected from (1) a shallow and deep monitoring well pair located upgradient of the ozonation system (KRY101A and KRY101B), (2) a shallow and deep monitoring well pair located near the ozonation system (KPT-7 and KPT-8) and (3) a shallow and deep monitoring well pair located approximately 200 feet downgradient of the

ozonation system (KRY114A and KRY114B). Groundwater samples from these well locations were additionally analyzed for bromate, chloride, and formaldehyde. Acetone was analyzed for as part of the standard suite of analytes with the VOCs (EPA Method 8260B). Results of these analyses are included in Appendix G.

Acetone, bromate, and formaldehyde were not detected in the groundwater samples collected from the monitoring wells listed above. It therefore does not appear that the ozonation system is creating potentially toxic byproducts resulting from degradation of PCP.

Chloride sampling results were inconclusive. All but one of the six monitoring wells sampled as part of the ozone effectiveness evaluation (monitoring well KRY101B) contained detectable concentrations of chloride at concentrations between 2 and 5 milligrams per liter (mg/L). Chloride concentration in well KRY101A located upgradient of the ozone treatment system was measured at 2.0 mg/L compared to a concentration of 2.0 mg/L in well KRY114A located downgradient of the ozone treatment system. The presence of chloride suggests the breakdown of PCP. However, historical groundwater data demonstrate that chloride levels typically range between 1 and 8 mg/L across the KRY Site. The ozonation system does not appear to be increasing chloride concentrations downgradient of the system.

### **LNAPL Investigation Results**

Groundwater from some monitoring wells located in the upper portion of the unconfined aquifer contained measurable LNAPL (Section 3.7 and Figure 3-9). In addition, other monitoring wells contained concentrations greater than 1 percent of the pure phase solubility of some chemicals. Samples with COPCs at concentrations greater than 1 percent of pure phase solubility suggests that free product is present in the groundwater at these locations. For example, PCP concentrations greater than 1 percent solubility were measured in monitoring wells KRY111A, KRY114A, KPT-2, and KPT-3. Table 4-6 provides physical and chemical properties of some COPCs including solubility and Appendix G provides complete groundwater analytical results. These samples generally correspond to wells where measurable LNAPL was recorded.

### **Natural Attenuation Parameter Results**

Assessments of microbiology and related parameters were conducted by WRI at the KRY Site (Appendix A). Groundwater samples were collected from selected monitoring wells and analyzed in the laboratory. Microcosms were also established to offer preliminary information for potential enhancement of in-situ biodegradation. Results demonstrate a diversity of anaerobic bacteria were present in the

groundwater onsite. These microbial populations include denitrifying, iron-reducing, sulfate-reducing, fermenting, methanogenic and dechlorinating bacteria. Denitrifying bacteria appear to be the dominant species that is present in high populations in groundwater. *Dehalococcoides sp.* was detected in high numbers in groundwater collected from wells on the PCP-contaminated sites, indicating active dechlorination of PCP. The enhancements to date applied to microcosms resulted in the increased growth of bacteria populations. Data suggest that denitrifying bacteria may be the most active population and responsible for a substantial amount of diesel-range petroleum biodegradation. This study suggests that in situ enhancement of denitrifying bacteria may increase the rate of diesel-range petroleum (and possibly other hydrocarbons) biodegradation at the Reliance facility. However, further studies are warranted to optimize the enhancement and maximize denitrifying bacteria activity and the rates of hydrocarbon biodegradation.

### **4.3 SURFACE SOIL INVESTIGATION RESULTS**

Surface soil samples were collected throughout the KRY Site during the RI sampling event in April through July 2006, including at the KPT, Reliance, and Yale Oil facilities, adjacent commercial properties, and at adjacent residential areas. In addition, surface soil results from previous investigations are discussed in this section and included in the statistical analyses and on the figures. A soil sample is considered a surface soil sample if the majority of the sample was obtained within a depth of 0 to 2 feet bgs. No chemicals other than dioxins and furans were detected at concentrations above screening criteria in surface soil samples collected from adjacent residential or background areas. Thirty-nine chemicals were detected in surface soil samples at concentrations above screening criteria (DEQ residential RBSL, DEQ commercial RBSL, EPA Region 9 residential PRG, EPA Region 9 industrial PRG, or EPA Region 9 SSL with a DAF of 10) as summarized in Table 4-2. Twenty-five of these chemicals are considered COPCs since they were detected at a frequency of greater than 5 percent and exhibited maximum concentrations greater than background. Fourteen additional chemicals or chemical groups are considered COPCs since they were detected at a frequency of greater than 5 percent, exhibited maximum concentrations greater than background, and do not have screening criteria. Surface soil sampling results for PCP, benzo(a)pyrene, dioxins and furans, lead, and C11-C22 aromatic hydrocarbons are presented on Figures 4-6A through 4-10D and are further discussed in this section. Complete analytical results for soil samples collected as part of this RI as well as previous investigations are provided in Appendix G.

## 8.2.0 Semi-volatile Organic Compound Results

Eight SVOCs (PCP, chrysene, benzo[b]fluoranthene, indeno[1,2,3-cd]pyrene, benzo[a]anthracene, benzo[a]pyrene, dibenzo[a,h]anthracene, and naphthalene) are considered COPCs since they were found in at least 5 percent of samples and exhibited maximum detected concentrations that exceeded the screening levels and background concentrations. All of these compounds are PAHs except PCP. Seven SVOCs (benzo(e)pyrene, benzo(b,k)fluoranthene, phenanthrene, benzo(g,h,i)perylene, 2,3,4,5-tetrachlorophenol, tetrachlorophenol, and acenaphthylene) are considered COPCs since they were detected in more than 5 percent of samples, exhibited maximum concentrations above background, and do not have screening criteria. Eleven SVOC compounds including eight PAHs were detected in background surface soil samples and all concentrations were below screening criteria. Results for PCP and benzo(a)pyrene are discussed below.

### Pentachlorophenol

Pentachlorophenol was detected in 261 surface soil samples with concentrations ranging from 0.0016 mg/kg to 6,900 mg/kg. Results for PCP for samples collected from 0 to 2 inches bgs are shown in Figure 4-6A; results for samples from 0 to 6 inches bgs are shown in Figure 4-6B; results for concentrations at a depth of 0 to 6 inches bgs in a detailed area at the KPT facility are shown on Figure 4-6C; results for samples from 0 to 2 feet bgs are shown in Figure 4-6D; and results for concentrations at a depth of 0 to 2 feet bgs inches in a detailed area at the KPT facility are shown on Figure 4-6E . A surface soil composite of all areas exceeding screening criteria is shown on Figure 4-6F. The highest concentrations of PCP in surface soil are located near the center of the KPT facility, within and east of the former excavation area. A small area of elevated PCP concentrations in surface soil is located within the Reliance Refinery, south of the railroad tracks. No PCP was detected in background surface soil samples (KRY560, KRY561, and KRY562). Concentrations of PCP in surface soil on approximately 2.5 acres of land within the KRY Site exceeded the EPA Region 9 residential PRG. Concentrations of PCP in surface soil exceeded EPA Region 9 industrial PRG on approximately 1.6 acres of land and exceeded EPA Region 9 DAF of 10 on approximately 40.2 acres of land.

### Benzo(a)pyrene

Benzo(a)pyrene was detected in 41 surface soil samples, with concentrations ranging from 0.009 mg/kg to 26 mg/kg. Benzo(a)pyrene is likely associated with petroleum products at the KRY Site. Results for benzo(a)pyrene in samples collected from 0 to 2 inches bgs are shown in Figure 4-7A; results for samples

collected from 0 to 6 inches bgs are shown in Figure 4-7B; results for concentrations at a depth of 0 to 6 inches bgs in a detailed area at the KPT facility are shown on Figure 4-7C; results for samples collected from 0 to 2 feet bgs are shown in Figure 4-7D; and results for concentrations at a depth of 0 to 2 feet bgs in a detailed area at the KPT facility are shown on Figure 4-7E. A surface soil composite of all areas exceeding screening criteria is shown on Figure 4-7F. The highest concentrations of benzo(a)pyrene in surface soil are located within the Reliance facility south of the railroad tracks. In addition, elevated concentrations of benzo(a)pyrene were detected at the Yale Oil facility. Contamination south of Office Max may be from a source other than the Yale Oil facility. Concentrations of benzo(a)pyrene in background surface soil samples (KRY560, KRY561, and KRY562) ranged from 0.042 mg/kg to 0.048 mg/kg. Concentrations of benzo(a)pyrene in surface soil on approximately 1.94 acres of land within the KRY Site exceeded the DEQ residential RBSL. Concentrations of benzo(a)pyrene in surface soil exceeded DEQ commercial RBSL on approximately 0.4 acres of land and exceeded EPA Region 9 DAF of 10 on approximately 0.1 acres of land.

### **8.2.0 Dioxins and Furans Results**

Dioxins and furans (2,3,7,8-TCDD TEQ) are considered COPCs since they were detected in at least 5 percent of surface samples and were detected at maximum detected concentrations that exceeded screening levels and background concentrations. Dioxins and furans were detected in 117 surface soil samples with calculated 2,3,7,8-TCDD TEQ concentrations ranging from 0.099 ng/kg to 171,510 ng/kg. Concentrations of 2,3,7,8-TCDD TEQ in background surface soil samples (KRY560, KRY561, and KRY562) ranged from 1.2 ng/kg to 4.8 ng/kg. Elevated dioxin and furan concentrations in surface soil are considered to be associated with PCP released at the site. 2,3,7,8-TCDD TEQ results for samples collected from 0 to 2 inches bgs are shown in Figure 4-8A; results for samples from 0 to 6 inches bgs are shown in Figure 4-8B; results for concentrations at a depth of 0 to 6 inches bgs in a detailed area at the KPT facility are shown on Figure 4-8C; and results for samples from 0 to 2 feet bgs are shown in Figure 4-8D. A surface soil composite of all areas exceeding screening criteria is shown on Figure 4-8E. The highest concentrations of 2,3,7,8-TCDD TEQ in surface soil are located within the KPT facility. Concentrations of the 2,3,7,8-TCDD TEQ in surface soil on approximately 49.3 acres of land within the KRY Site exceeded the EPA Region 9 residential PRG. Concentrations of 2,3,7,8-TCDD TEQ in surface soil exceed EPA Region 9 industrial PRG on approximately 38.1 acres of land and exceeded site-specific background concentrations on 45.3 acres of land. The presence of elevated dioxins at 2 feet bgs suggests a source associated with onsite activities and not necessarily wind deposited contamination.

Elevated concentrations of 2,3,7,8-TCDD TEQ in surface soil above background (4.8 ng/kg) but below the EPA Region 9 industrial PRG (15.9 ng/kg) were found in five samples from residential areas located east, south, and west of the KRY Site. The 2,3,7,8-TCDD TEQ concentrations were measured at 5.3 ng/kg at KRY430, 9.7 ng/kg at KRY483, 8.1 ng/kg at KRY550, 6.2 ng/kg at KRY551, and 9.0 ng/kg at KRY 558.

### **8.2.0 Volatile Organic Compound Results**

Two VOCs (benzene and methylene chloride) were detected in surface soil samples at a maximum concentration that exceeded the screening criteria. Both are considered COPCs since they were detected in at least 5 percent of samples and exhibited maximum concentrations above background. Benzene concentrations ranged from 0.008 mg/kg to 0.056 mg/kg. Methylene chloride concentrations ranged from 0.006 mg/kg to 7.14 mg/kg. No VOCs were detected in background surface soil samples (KRY560, KRY561, and KRY562). No tetraethyllead was detected in surface soil samples.

### **8.2.0 Petroleum Hydrocarbon Results**

Six petroleum hydrocarbon groups (TEH, total petroleum hydrocarbons, C19-C36 aliphatics, C11-C22 aromatics, C9-C18 aliphatics, and C9-C12 aliphatics) are considered COPCs since they were detected in at least 5 percent of surface soil samples and exhibited maximum detected concentrations that exceeded screening levels and background concentrations. Seven other petroleum groups (C10-C22 aliphatics, C10-C22 aromatics, diesel, diesel range organics, diesel range organics as diesel, gasoline range organics, and total purgeable hydrocarbons) are considered COPCs since they were detected in at least 5 percent of surface soil samples, were detected at maximum concentrations greater than background concentrations, and do not have screening criteria. TEH were detected in 140 of 155 samples and concentrations ranged from 7.8 mg/kg to 44,000 mg/kg. Only two petroleum hydrocarbons, TEH and C11-C22 aromatic hydrocarbons, were detected in background surface soil samples (KRY560, KRY561, and KRY562); both were detected at concentrations below screening criteria. TEH concentrations ranged from 19 mg/kg to 136 mg/kg. Results for C11-C22 aromatic hydrocarbons are discussed below.

#### **C11-C22 Aromatic Hydrocarbons**

C11-C22 aromatic hydrocarbons were detected in 84 surface soil samples with concentrations ranging from 7.8 mg/kg to 14,100 mg/kg. C11-C22 aromatic hydrocarbon contamination is likely associated with diesel or other carrier oils used in wood treating operations at the KPT facility and petroleum feedstocks and products at the Reliance and Yale Oil facilities. C11-C22 aromatic hydrocarbon results for samples

collected from 0 to 2 inches bgs are shown in Figure 4-9A; results for samples from 0 to 6 inches bgs are shown in Figure 4-9B; results for concentrations at a depth of 0 to 6 inches bgs in a detailed area at the KPT facility are shown on Figure 4-9C; and results for samples from 0 to 2 feet bgs are shown in Figure 4-9D. A surface soil composite of all areas exceeding screening criteria is shown on Figure 4-9E. The highest concentrations of C11-C22 aromatic hydrocarbons in surface soil are located within the Reliance facility in an area along the eastern border of the facility and a small area just north of the railroad tracks. Three samples associated with the Yale Oil facility exhibited elevated concentrations of C11-C22 aromatic hydrocarbons. Two samples were above the DEQ Residential RBSL (KRY605 and KRY409). One sample (KRY666) was above both DEQ residential and commercial RBSLs. Contamination south of Office Max may be from a source other than the Yale Oil facility. C11-C22 aromatic hydrocarbons were detected in only one background surface soil sample (KRY562) at a concentration of 11 mg/kg. Concentrations of C11-C22 aromatic hydrocarbons in surface soil on approximately 5.9 acres of land within the KRY Site exceeded the DEQ residential RBSL. Concentrations of C11-C22 aromatic hydrocarbons in surface soil exceeded DEQ commercial RBSL on approximately 1.8 acres of land

## **8.2.0 Metals Results**

Eight metals (aluminum, arsenic, chromium, iron, lead, manganese, thallium, and vanadium) are considered COPCs since they were detected in at least 5 percent of surface soil samples and exhibited maximum detected concentrations that exceeded the screening levels and background concentrations. Detectable aluminum concentrations ranged from 2,950 mg/kg to 54,800 mg/kg. Detectable arsenic concentrations ranged from 1.48 mg/kg to 240.7 mg/kg. Detectable chromium concentrations ranged from 6.1 mg/kg to 27.8 mg/kg. Detectable iron concentrations ranged from 4,930 mg/kg to 25,500 mg/kg. Detectable manganese concentrations ranged from 4,930 mg/kg to 25,500 mg/kg. Detectable thallium concentrations ranged from 0.4 mg/kg to 1.3 mg/kg. Detectable vanadium concentrations ranged from 3 mg/kg to 35.5 mg/kg. Results for lead are discussed below. All background concentrations of these metals were below screening criteria.

### **Lead**

Lead was detected in 119 of 122 surface soil samples with concentrations ranging from 7 mg/kg to 44,300 mg/kg. Lead at the KRY Site is likely associated with petroleum refining and products at the Reliance facility, although no evidence of a lead additive facility has been found. All surface soil sampling locations with concentrations of lead above screening criteria are within the southern portion of the Reliance facility except for one sample (SS-4-91) at the KPT facility. Results for lead in samples

collected from 0 to 2 inches bgs are shown in Figure 4-10A; results for samples from 0 to 6 inches bgs are shown in Figure 4-10B; results for samples from 0 to 2 feet bgs are shown in Figure 4-10C; and results for concentrations at a depth of 0 to 2 feet bgs in a detailed area at the Reliance facility are shown on Figure 4-10D. A surface soil composite of all areas exceeding screening criteria is shown on Figure 4-10E. The highest concentrations of lead in surface soil are located near the southern boundary of the Reliance facility. Concentrations of lead in background surface soil samples (KRY560, KRY561, and KRY562) ranged from 10 mg/kg to 15.3 mg/kg. Concentrations of lead in surface soil on approximately 0.9 acres of land within the KRY Site exceeded the EPA Region 9 residential PRG. Concentrations of lead in surface soil exceeded the EPA Region 9 industrial PRG on approximately 0.4 acres of land.

#### **4.3.6 Other Parameters Results**

Sludge and oily waste samples were collected from two locations (KRY415 and KRY422) within the former Reliance facility and vicinity as part of the surface soil investigation. In addition to the standard suite and dioxins and furans analysis, the sludge samples were also analyzed for PCBs and for TCLP analysis to assist in evaluating characteristics and disposal options.

PCBs were not detected in either of the samples. Additionally, none of the chemical constituents analyzed as part of TCLP were detected. Therefore, the sludge and oily waste located at KRY415 and KRY422 are not considered a characteristic hazardous waste per RCRA regulatory limits for disposal and treatment (Table 1 of 40 CFR 261.24) based on toxicity. However, transportation and off-site disposal of contaminated materials from the KRY Site may still require characteristic hazardous waste determination for ignitability, corrosivity, and reactivity. Results for PCBs and TCLP are presented in the data summary tables in Appendix G.

One surface soil sample from the KPT facility was obtained from borehole location KRY657 (sample KRY657SS002 from 0 to 6 inches bgs) for SVOC, VOC, and metals analyses after SPLP extraction. Samples were obtained for SPLP analysis to evaluate leaching potential to groundwater, metals mobility, and DAFs. This sample was collected from an area exhibiting relatively low-level contamination; no chemical constituents analyzed as part of the SPLP analysis were detected in this sample. Two constituents were detected in the corresponding soil sample (KRY657SS01 from 0 to 6 inches bgs). PCP was detected at a concentration of 3 mg/kg. All other analytes that were not detected in the SPLP sample were also not detected in the corresponding soil sample. The complete results for these samples are shown in Appendix G.

#### **4.4 SUBSURFACE SOIL INVESTIGATION RESULTS**

Subsurface soil sampling was conducted throughout the KRY Site during the RI sampling event in May through June 2006, including at the KPT, Reliance and Yale Oil facilities, adjacent commercial properties, and adjacent residential areas. In addition, subsurface soil results from previous investigations are discussed in this section and included in the statistical analyses and on the figures. A soil sample is considered subsurface soil sample if the majority of the sample was obtained below 2 feet bgs. No chemicals were detected at concentrations above screening criteria in subsurface soil from adjacent residential areas. Forty-three chemicals were detected in subsurface soil samples at concentrations above screening criteria (DEQ subsurface RBSL, DEQ residential RBSL, DEQ commercial RBSL, EPA Region 9 residential PRG, EPA Region 9 industrial PRG, or EPA Region 9 SSL with a DAF of 10) as summarized in Table 4-3. Thirty-three of these chemicals are considered COPCs since they were detected at a frequency of greater than 5 percent and exhibited maximum concentrations greater than background. Thirteen additional chemicals or chemical groups are considered COPCs since they were detected at a frequency of greater than 5 percent, are not essential nutrients, and do not have screening criteria. The full list of subsurface soil COPCs is presented in Table 4-3. Subsurface soil sampling results for PCP, benzo(a)pyrene, dioxins and furans, C9-C18 aromatic hydrocarbons, and lead are presented on Figures 4-11 through 4-16 and are further discussed in this section. Complete analytical results are provided in Appendix G.

##### **3.3.0 Semi-Volatile Organic Compound Results**

Eleven SVOCs (PCP, carbazole [an aromatic hydrocarbon found in crude oil], benzo[b]fluoranthene, benzo[k]fluoranthene, fluorene, benzo[a]anthracene, benzo[a]pyrene, naphthalene, pyrene, dibenzofuran, and acenaphthene) are considered COPCs since they were detected in at least 5 percent of subsurface soil samples and were detected at maximum concentrations that exceeded screening levels and background concentrations. All of these compounds are PAHs except for PCP, dibenzofuran, and carbazole. Five additional SVOCs (phenanthrene, 2-methylnaphthalene, 2,6-dimethylnaphthalene, acenaphthylene, and 1-methylnaphthalene) are considered COPCs since they were detected in at least 5 percent of samples, were detected at maximum concentrations that exceeded background, and do not have screening criteria. Results for PCP and benzo(a)pyrene are discussed below.

### **Pentachlorophenol**

Pentachlorophenol was detected in 128 subsurface soil samples, with concentrations ranging from 0.0014 mg/kg to 2,200 mg/kg. Results for PCP in subsurface samples are shown in Figure 4-11A; results shown on the figure are the highest concentration detected at each location and the associated sample depth. Results for a detailed area at the KPT facility are shown on Figure 4-11B and results for a detailed area of the Reliance facility are shown on Figure 4-11C. The highest concentrations of PCP in subsurface soil are located within and downgradient of the KPT facility. Concentrations of PCP in subsurface soil on approximately 2.6 acres of land within the KRY Site exceeded the EPA Region 9 residential PRG. Concentrations of PCP in surface soil exceeded EPA Region 9 industrial PRG on approximately 2.0 acres of land and exceeded EPA Region 9 DAF of 10 on approximately 15.0 acres of land.

### **Benzo(a)pyrene**

Benzo(a)pyrene was detected in 28 subsurface soil samples, with concentrations ranging from 0.0123 mg/kg to 8 mg/kg. Benzo(a)pyrene results for subsurface soil samples are shown in Figure 4-13A; results shown on the figure are the highest concentration detected at each location and the associated sample depth. Results for a detailed area at the KPT facility are shown on Figure 4-13B; results for a detailed area of the Reliance facility are shown on Figure 4-13C; and results for a detailed area of the Yale Oil facility are shown on Figure 4-13D. The highest concentrations of benzo(a)pyrene in subsurface soil are located within the KPT and Reliance facilities. Benzo(a)pyrene concentrations exceeded DEQ residential and commercial RBSLs in samples from the KPT, Reliance, and Yale Oil facilities. Concentrations of benzo(a)pyrene in subsurface soil on approximately 0.8 acres of land within the KRY Site exceeded the DEQ residential RBSL. Concentrations of benzo(a)pyrene in subsurface soil exceeded DEQ commercial RBSL on approximately 0.2 acres of land and exceeded EPA Region 9 DAF of 10 on less than 0.1 acres of land.

### **3.3.0 Dioxins and Furans Results**

Dioxins and furans (2,3,7,8-TCDD TEQ) are considered a COPC since they were detected in at least 5 percent of subsurface soil samples and were detected at maximum concentrations that exceeded screening levels and background concentrations. Dioxins and furans were detected in 63 subsurface soil samples with calculated 2,3,7,8-TCDD TEQ concentrations ranging from 0.249 ng/kg to 20,652 ng/kg. Results for 2,3,7,8-TCDD TEQ for subsurface samples are shown in Figure 4-12; results shown on the figure are the highest concentration detected at each location and the associated sample depth. The highest

concentrations of 2,3,7,8-TCDD TEQ in subsurface soil are located within the KPT facility.

Concentrations of 2,3,7,8-TCDD TEQ in subsurface soil on approximately 7.6 acres of land within the KRY Site exceeded the EPA Region 9 residential PRG. Concentrations of 2,3,7,8-TCDD TEQ in subsurface soil exceeded EPA Region 9 industrial PRG on approximately 5.4 acres of land and exceeded site-specific background concentrations on 6.5 acres of land.

### **3.3.0 Volatile Organic Compound Results**

Five VOCs (ethylbenzene, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, toluene, and xylenes) are considered COPCs since they were detected in at least 5 percent of subsurface soil samples at maximum concentrations that exceeded screening levels and background concentrations. One additional SVOC (4-isopropyltoluene) is considered a COPC since it was detected in at least 5 percent of samples, exhibited maximum concentrations that exceeded background, and has no screening criteria. No tetraethyllead was detected in subsurface soil samples.

### **3.3.0 Petroleum Hydrocarbon Results**

Eight petroleum hydrocarbon groups (total petroleum hydrocarbons, TEH, C19-C36 aliphatics, C11-C22 aromatics, C9-C18 aliphatics, C9-C10 aromatics, C5-C8 aliphatics, and C9-C12 aliphatics) are considered COPCs since they were detected in at least 5 percent of subsurface soil samples and were detected at maximum concentrations that exceeded screening levels and background. Seven additional petroleum groups (C10-C22 aliphatics, C10-C22 aromatics, total purgeable hydrocarbons, gasoline range organics, diesel, diesel range organics, and diesel range organics as diesel) are considered COPCs since they were detected in at least 5 percent of subsurface soil samples, exhibited maximum concentrations that exceeded background, and have no screening criteria. TEH were detected in 161 of 196 samples and concentrations ranged from 7.5 mg/kg to 566,000 mg/kg. Results for C9-C18 aliphatic hydrocarbons are discussed below.

#### **C9-C18 Aliphatic Hydrocarbons**

C9-C18 aliphatic hydrocarbons were detected in 138 subsurface soil samples, with concentrations ranging from 3 mg/kg to 163,000 mg/kg. C9-C18 aliphatic hydrocarbon results for subsurface samples are shown in Figure 4-15A; results shown on the figure are the highest concentration detected at each location and the associated sample depth. Results for a detailed area at the KPT facility are shown on Figure 4-15B and results for a detailed area of the Reliance facility are shown on Figure 4-15C. The highest concentrations of C9-C18 aliphatic hydrocarbons in subsurface soil are located within the Reliance

facility. Concentrations of C9-C18 aliphatic hydrocarbons in subsurface soil on approximately 9.2 acres of land within the KRY Site exceeded the DEQ residential RBSL. Concentrations of C9-C18 aliphatic hydrocarbons in subsurface soil exceeded DEQ commercial RBSL on approximately 5.2 acres of land and exceeded DEQ subsurface soil RBSL on approximately 4.3 acres of land.

### **3.3.0 Metals Results**

Eight metals (aluminum, arsenic, chromium, iron, lead, manganese, selenium, and vanadium) are considered COPCs since they were detected in at least 5 percent of subsurface soil samples and exhibited maximum detected concentrations that exceeded the screening levels and background concentrations. Detectable aluminum concentrations ranged from 4,300 mg/kg to 17,900 mg/kg. Detectable arsenic concentrations ranged from 1.06 mg/kg to 58.4 mg/kg. Detectable chromium concentrations ranged from 4 mg/kg to 29.2 mg/kg. Detectable iron concentrations ranged from 5,000 mg/kg to 53,200 mg/kg. Detectable manganese concentrations ranged from 82.9 mg/kg to 668 mg/kg. Detectable selenium concentrations ranged from 0.7 mg/kg to 5.5 mg/kg. Detectable vanadium concentrations ranged from 3.5 mg/kg to 17.7 mg/kg. Results for lead are discussed below.

### **Lead**

Lead was detected in 137 subsurface soil samples, with concentrations ranging from 5 mg/kg to 4,190 mg/kg. Results for lead in subsurface samples are shown in Figure 4-15A; results shown on the figure are the highest concentration detected at each location and the associated sample depth. Results for a detailed area at the KPT facility are shown on Figure 4-15B and results for a detailed area of the Reliance facility are shown on Figure 4-15C. The highest concentration of lead in subsurface soil is located within the Reliance facility. Concentrations of lead in subsurface soil on approximately 0.1 acres of land within the KRY Site exceeded the EPA Region 9 residential PRG. Concentrations of lead in subsurface soil exceeded the EPA Region 9 industrial PRG on less than 0.1 acres of land.

### **4.4.6 Other Parameters Results**

Two subsurface soil samples were obtained from boreholes located on the KPT facility (KRY658 and KRY669), and one subsurface soil sample was collected from the Reliance facility when LNAPL monitoring well KRY137A was installed during the subsurface soil investigation. The samples were collected from mid- to high-level areas of contamination and submitted for SVOC, VOC, and metals analyses after SPLP extraction. These results along with corresponding soil sampling results will be used in developing a site-specific soil screening level to effectively assess the risk posed by PCP leaching into

the shallow groundwater system. Results of the SPLP analysis for these samples are shown in the summary tables in Appendix G.

PCP and chloroform were the only compounds detected in samples analyzed after SPLP extraction. PCP was detected at 3.3 mg/L in the SPLP sample from boring KRY658 (collected from 15.5 to 17 feet bgs), which is above the DEQ human health groundwater standard of 1 µg/L and above the EPA Region 9 tap water PRG of 0.56 µg/L. PCP concentration in an adjacent soil sample from boring KRY658 (collected from 14 to 15.5 feet bgs) was measured at 318 mg/kg. This boring is located approximately in the center of the former excavation area on the KPT facility. All other organic analytes that were not detected in the SPLP sample were also not detected in the corresponding adjacent soil sample. Arsenic, barium, and chromium were detected in the adjacent soil sample but not detected in the SPLP sample.

Chloroform was detected at 1.3 µg/L in the SPLP sample from monitoring well KRY137A on the Reliance facility (collected from 9 to 10 feet bgs). This value is below the DEQ human health groundwater standard of 70 µg/L but above the EPA Region 9 tap water PRG of 0.17 µg/L. Chloroform was not detected in any soil samples collected at similar depths from other borings in the vicinity of KRY137A (KRY 126A, KRY136A, and KRY610). All other organic analytes that were not detected in the SPLP sample were also not detected in the corresponding nearby soil samples. A number of metals were detected in the corresponding nearby soil samples but not detected in the SPLP sample.

No analytes were detected in the SPLP sample from boring KRY669 (collected from 14 to 19 feet bgs). Soil samples at similar depths from borings in the vicinity of KRY669 contained PCP concentrations at 7 mg/kg (KRY638), at 0.0053 mg/kg (KRY639), and 0.0027 mg/kg (KRY111A). All other organic analytes that were not detected in the SPLP sample were also not detected in the corresponding nearby soil samples. A number of metals were detected in the corresponding nearby soil samples but not detected in the SPLP sample.

### **Physical Parameters Results**

Soil samples collected when monitoring wells KRY115A, KRY121A, and KRY139B were installed were submitted for analysis of various physical properties in soil. Physical parameters included particle size, plasticity, moisture content, specific gravity, porosity, and pH. The soil type was also classified using the ASTM International D2487 USCS. In addition, two subsurface soil samples were collected and analyzed for TOC when monitoring well KRY121B was installed. The results of the analysis will be used to provide input parameters for future development of contaminant and fate transport models. A summary

of the physical parameters is presented in Table 4-7, and the complete results are provided in Appendix G.

#### **4.5 SURFACE WATER AND SEDIMENT INVESTIGATION RESULTS**

Surface water and sediment samples were collected from the Stillwater River adjacent to the KPT and Reliance facilities in June and July 2006. Detected analytes include metals, SVOCs, and petroleum compounds. Two chemicals (2,3,7,8-TCDD TEQ and aluminum) were detected in surface water samples at concentrations above screening criteria (DEQ human health standards and DEQ aquatic life standards) as summarized in Table 4-4. 2,3,7,8-TCDD TEQ concentrations ranged from 0.07 pg/L to 2.17 pg/L compared to the DEQ human health standard of 0.05 pg/L. Aluminum concentrations ranged from 180 µg/L to 250 µg/L. Background surface water concentrations of 2,3,7,8-TCDD TEQ (0.29 pg/L) and aluminum (250 µg/L) were measured at the most upgradient surface water station (KRY200). Since the background concentration for aluminum is the highest concentration measured, only 2,3,7,8-TCDD TEQ is considered a COPC for surface water.

No chemicals were detected in sediment samples at concentrations above screening criteria (freshwater sediment criteria) as summarized in Table 4-5. Detected concentrations of petroleum compounds below screening criteria were found in the sediment sample collected at the upgradient location (KRY200). Detected concentrations of SVOCs and petroleum compounds below screening criteria were found in the sediment sample collected near the Montana Mokko property (KRY202). Complete analytical results are provided in Appendix G.

#### **4.6 SUMMARY OF NATURE AND EXTENT OF CONTAMINATION**

This section presents a summary of the nature and extent of contamination at the KRY Site, including a summary of contaminant sources and resulting groundwater contamination where concentrations of COPCs exceeded regulatory levels and may require remedial action.

##### **10.5.0 Sources of Contamination**

Three primary sources of groundwater contamination have been identified at the KRY Site based on results for soil and groundwater samples from previous investigations and this RI. These sources have been identified as the KPT facility source area, the Reliance Refinery facility source area, and the Yale Oil facility source area. One off-site source of groundwater contamination was identified at the Seaman Shelton site (near Northern Energy Propane). No other source areas have been identified based on the

results of groundwater and soil sampling. Primary sources of organic COPCs appear to be at the KPT and Reliance facilities with lesser sources at the Yale Oil facility. Soil contamination south of Office Max may be from a source other than the Yale Oil facility. A removal action at the Yale Oil facility in 1993 (see Section 1.4.3) included the excavation and treatment of a large volume of organic source material. The primary source of inorganic contamination appears to be elevated lead concentrations in surface soil in the southern portion of the Reliance facility. Summaries of samples where chemical concentrations exceeded site-specific screening criteria are provided in Tables 4-1 through Table 4-5. Surface and subsurface soil with COPCs at concentrations above site-specific screening criteria are considered potential sources for groundwater contamination. No surface or subsurface samples from locations outside the identified source areas contained COPCs at concentrations above screening criteria, except that surface soil samples in some residential areas contained dioxin and furans at levels slightly above the residential PRG and one subsurface soil sample north of the northeast corner of the KPT facility exhibited elevated levels of C9-C18 aliphatic hydrocarbons above residential, commercial, and subsurface soil screening criteria (see Figure 4-14A).

#### **4.6.2 Groundwater Impacts**

The highest concentrations of groundwater contamination by PCP at the KRY Site have been reported within and downgradient of the KPT facility source area. High concentrations of petroleum hydrocarbons have been reported at all three facilities and off-site at the Seaman Shelton site (near Northern Energy Propane). Petroleum contamination, specifically benzene contamination, at the Seaman Shelton site does not appear to be related to or connected with petroleum contamination at the KPT, Reliance Refinery, and Yale Oil facilities. Groundwater contamination south of Office Max may be from a source other than the Yale Oil facility.

#### **4.6.3 Surface Water and Sediment Impacts**

One COPC (2,3,7,8-TCDD TEQ) was reported in surface water samples at concentrations greater than the DEQ human health standard (DEQ 2006b) and background concentrations. No COPCs were reported in sediment at concentrations above site-specific screening criteria. Surface water elevations in the Stillwater River were greater than local groundwater elevations during July and August 2006 at the monitoring sites. These data indicate that surface water likely recharged local groundwater during the time period of measurement, and that little or no discharge of groundwater to surface water was expected along these reaches of stream. Existing water level information is limited and does not allow for seasonal relationships to be established for interactions between groundwater and surface water. Currently, DEQ

is collecting monthly groundwater and surface water elevation data that can be used to evaluate seasonal trends, if present.

## 5.0 CONTAMINANT FATE AND TRANSPORT

This section presents fate and transport information for COPCs at the KRY Site. Site physical characteristics, contaminant characteristics, and an analysis of the fate and transport processes are combined in the evaluation of contaminant fate and transport. The contaminant fate and transport processes at the KRY Site are addressed in the following sections:

- Section 5.1 describes the general physical and chemical properties of the COPCs.
- Section 5.2 describes the general toxicological properties of the COPCs and presents TEFs for dioxins and furans
- Section 5.3 describes the fate and transport processes of the COPCs, particularly a presentation of destructive and nondestructive attenuation processes
- Section 5.4 describes the Conceptual Site Model, including a summary of sources and release mechanisms, pathways for exposure, receptors, and the approach to risk analysis.

### 5.1 PROPERTIES OF CONTAMINANTS OF POTENTIAL CONCERN

The COPCs as identified in the RI are shown in Table 4-6. The RI considered five COPCs or groups of COPCs the most significant from a risk and remediation standpoint and these are discussed in this section: PCP, dioxins and furans, PAHs, petroleum hydrocarbons, and lead. The following subsections discuss the physical and chemical characteristics along with the toxicological effects of each of the COPCs. In addition, the typical breakdown products and parent compounds are described.

#### 5.1.1 Pentachlorophenol

PCP is a white organic solid with needle-like crystals and a very sharp, phenolic odor. It is produced by the chlorination of phenol. Impure PCP, which is most likely to be found at hazardous waste sites, is a dark gray to brown dust, beads, or flakes (National Safety Council [NSC] 2005). The largest use of PCP is as a wood preservative (fungicide) for utility poles, cross arms, fence posts, and similar structures. PCP was used at the KPT facility as a wood preservative. Though once widely used as an herbicide, it was banned in 1987 for these and other uses, as well as for over-the-counter sales (EPA 2005).

PCP does not occur naturally in the environment. It enters the environment through evaporation from treated wood surfaces, industrial spills and drippage, and disposal at uncontrolled hazardous waste sites. PCP is a non-flammable solid, which does not evaporate easily. The density of PCP is 1.978 g/mL at 22 °C (ASDSR 2001a), and the Henry's Law Constant is  $2.4 \times 10^{-8}$  atmospheres per cubic meter per mole

(atm-m<sup>3</sup>/mol). Compounds with values less than 10<sup>-5</sup> atm-m<sup>3</sup>/mol volatilize from water only to a limited extent (Lyman and others 1982).

PCP is an ionizing organic compound (EPA, 1996). The extent of ionization, which affects the solubility of PCP and its partitioning between water and soil, is pH dependant. At pH 7 and higher, over 99 percent of dissolved PCP is present as the ionized species C<sub>6</sub>Cl<sub>5</sub>O<sup>-</sup>. Equal amounts of the ionized and neutral species (C<sub>6</sub>Cl<sub>5</sub>OH) are present around pH 4.8, and the neutral species is dominant at lower pH. The ionized species has a higher aqueous solubility and lower affinity for soil sorption than the neutral species (EPA, 1996). The organic carbon partition coefficient (K<sub>oc</sub>) indicates the affinity to bind to organic carbon in soils and sediment. At neutral pH, PCP is less mobile in subsurface soil and groundwater than gasoline range petroleum hydrocarbon compounds, but is more mobile than diesel range petroleum hydrocarbons.

### **5.1.2 Dioxins and Furans**

Chlorinated dibenzo-p-dioxins (CDD) and chlorinated dibenzo furans (CDF) are a family of chemically related compounds commonly known as chlorinated dioxins and furans (ATSDR 1998). Dioxins may be naturally produced from the incomplete combustion of organic material by forest fires or volcanic activity. Dioxins are not intentionally manufactured by industry, except in small amounts for research. They are unintentionally produced by industrial, municipal, and domestic incineration and combustion processes. Dioxins and furans are always found with PCP and it is considered the primary source of dioxin and furan contamination at the KRY Site.

One dioxin compound (2,3,7,8-TCDD) is one of the most toxic of the CDDs and is the one most studied. The Henry's Law Constant for 2,3,7,8-TCDD is 7.0 x 10<sup>-8</sup> atm-m<sup>3</sup>/mol, and the K<sub>oc</sub> value is 6.0 x 10<sup>6</sup>.(EPA, 2004). These values indicate a strong affinity for soil, and limited volatilization of 2,3,7,8-TCDD dissolved in water.

Combustion generated chlorinated dioxins may be transported long distances (as vapors or associated with particulates) in the atmosphere (Czuczwa and Hites 1986a, 1986b; Tysklind and others 1993). They may eventually be deposited on soils, surface waters, or vegetation as a result of dry or wet deposition. Chlorinated dioxins, unless present in carrier solutions (such as is the case at the KRY Site), typically do not leach to underlying groundwater but may enter the atmosphere on soil dust particles or enter surface waters on soil particles in surface runoff. When it is present in carrier solutions (such as diesel), dioxin may migrate with the carrier solution in the vadose zone and groundwater. Low water solubility and high

lipophilicity indicate that chlorinated dioxins will bioconcentrate in aquatic organisms, although, because they bind to suspended organic matter, the actual uptake by these organisms may be less than predicted.

### **5.1.3 Polycyclic Aromatic Hydrocarbons**

The compounds acenaphthylene, acenaphthene, anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthrene, fluorene, indeno(1,2,3-CD)pyrene, phenanthrene, pyrene, and naphthalene belong to the group of compounds known as PAHs. PAHs are defined as hydrocarbons containing two or more aromatic rings. PAHs are released to the environment from natural and manmade sources. Manmade sources now provide a much larger release volume than do natural sources. PAHs are common constituents of petroleum hydrocarbon mixtures such as diesel, motor oil, and asphalt. PAHs also result from incomplete burning of coal, oil and gas, garbage, or other organic substances such as tobacco or charbroiled meat. They are also found in creosote, dyes, paints, plastics, insulating materials, building materials, and rubber.

In general, PAHs have low water solubility and may increasingly sorb to soil or particles within groundwater with increasing soil organic carbon. The less organic carbon found in the soil system, the more mobile are the PAH compounds. Sorption to soil particles is the primary process responsible for their removal from aqueous systems. The Henry's Law constants of PAHs range from  $10^{-4}$  to  $10^{-8}$  atm-m<sup>3</sup>/mol. The  $K_{oc}$  values for the high-molecular-weight PAHs are in the range of  $10^5$  to  $10^6$ , which indicates a strong tendency to adsorb to organic carbon present in soil (ATSDR 2001b).

Sorption of PAHs to soil and sediment increases with increasing organic carbon content and is also directly dependent on particle size. Smaller particles with higher surface-area-to-volume ratios are more efficient at sorbing PAHs. Sorption has been correlated with bioconcentration in aquatic organisms.

### **5.1.4 Petroleum Hydrocarbons**

“Petroleum hydrocarbons” is a term used to describe a large family of several hundred chemical compounds that originally come from crude oil (ATSDR 1999). Petroleum hydrocarbons are typically used as fuels, solvents, or chemical intermediates. The volatility of a compound generally decreases with an increase in carbon number range and boiling range. For the RI, petroleum hydrocarbons are generally classified in two groups: VPH and EPH.

The EPH or TPH-e (total petroleum hydrocarbons-extractable) group includes diesel-range organic compounds, motor oil range compounds, and other extractable fuels. EPH found in the environment at the KRY Site is associated with wood-treating and the petroleum refinery, as well as leaks from the Reliance and Yale Oil facilities. Contamination south of Office Max may be from a source other than the Yale Oil facility. The EPH or diesel-range organic compounds and motor oil range compounds are composed primarily of aliphatic hydrocarbons that fall in the C10 to C20 range. As much as approximately 25 percent of petroleum hydrocarbons may be composed of aromatic hydrocarbons consisting of alkylated benzenes and naphthalenes. Petroleum hydrocarbons are generally less dense than water. Diesel range organic compounds are less volatile, less water soluble, and less mobile than gasoline range organic compounds. Diesel-range organic compounds and motor oil range compounds have a stronger tendency for absorption to soil organic carbon.

The VPH group includes lighter gasoline-range organic compounds, jet fuel, mineral spirits, and other volatile fuels. VPH is found at the KRY Site associated with wood treating fluids used at the KPT facility and petroleum products used or produced at the Reliance and Yale Oil facilities. VPH or gasoline-range organic compounds are composed of both aromatic and aliphatic hydrocarbons. Volatile aliphatic hydrocarbons are collectively quantified within two ranges: C5 through C8, and C9 through C12. Volatile aromatic hydrocarbons are collectively quantified within the C9 to C10 range. Target VPH analytes include benzene, toluene, ethylbenzene, xylenes (BTEX).

### **5.1.5 Lead**

Lead is a constituent of many minerals and is a commonly detected element in soils and sediments. Lead is also found historically in many manmade products, including fuels, paints, and batteries. Naturally occurring lead in soils is often strongly sorbed to sediments, particularly fine-grained material that contains clay. Generally, lead does not tend to be mobile in aquatic environments. The presence of elevated lead concentrations at the KRY Site is believed to be associated with activities or processes at the Reliance facility; however, no specific historic information indicates that a lead additive process was used. Some crude oils contain metals; therefore, this is another possible source of lead.

Most lead is retained strongly in soil and very little is transported into surface water or groundwater (EPA 1979a; National Science Foundation [NSF] 1977). Clays, silts, iron and manganese oxides, and organic matter in soil can bind metals electrostatically (cation exchange) as well as chemically specific adsorption (Reed and others 1995). Lead is strongly sorbed to organic matter in soil. The downward movement of

elemental lead and inorganic lead compounds from soil to groundwater by leaching is very slow under most natural conditions, except for highly acidic situations (NSF 1977).

## **5.2 GENERAL TOXICOLOGICAL INFORMATION**

This section describes general toxicological information of chemicals identified as COPCs.

### **5.2.1 Pentachlorophenol**

PCP is significantly toxic to mammals, plants, and many microorganisms. However, bacteria have been found that are resistant to relatively high PCP concentrations and can metabolize it to carbon dioxide and chloride. Bacteria have been successful in the bioremediation of PCP (University of Minnesota Biocatalysis/Biodegradation Database 2005).

PCP can enter the body when breathed in with air, consumed with contaminated food or water, absorbed through dermal contact, or through incidental ingestion from contaminated soil. Exposure to high levels of PCP can cause the cells in the body to produce excess heat. In that case, a person may experience a very high fever, profuse sweating, and difficulty breathing. At this time, the body temperature may increase to dangerous levels, causing injury to various organs and tissues and possibly death. Liver effects and damage to the immune system have also been observed in humans exposed to high levels of PCP for a long time (ATSDR 2001a). PCP is a Class B probable human carcinogen.

PCP is expected to bioconcentrate because of its low water solubility, but the bioconcentration factor will depend on the pH of the water since PCP will be more dissociated at higher pHs (EPA 2006b). As a result, bioconcentration in fish will be moderate.

### **5.2.2 Dioxins and Furans**

Dioxins are known to be human carcinogens based on sufficient evidence of carcinogenicity from studies in humans (U.S. Department of Health and Human Services 2002). Studies published through 1996 demonstrated statistically significant increases in relative risks for all cancers combined, lung cancer, and non-Hodgkin's lymphoma among highly exposed sub-cohorts. Many independent animal studies of 2,3,7,7-TCDD have all found 2,3,7,8-TCDD to be carcinogenic. Tumors have been produced in rats, mice, and hamsters, in both sexes, in various strains, in multiple organs and tissues, and from multiple routes of dosing, including gastrointestinal (gastric instillation or dietary), dermal, and intraperitoneal. Exposure to TCDD leads to an increased frequency of cancers in a dose-dependent fashion. Increased

incidences of cancers in laboratory animals after exposure to TCDD include the following organs or systems: hepatobiliary, thyroid, lymphatic, respiratory, adrenal cortex, hard palate, nasal turbinates, tongue, and skin (Huff and others 1994). EPA considers dioxins and furans to be probable human carcinogens, while the World Health Organization (WHO) considers them to be known human carcinogens.

The most common noncarcinogenic effects for contact with dioxins via dermal contact and incidental ingestion are presented below. The most widely recognized effect of dermal exposure is chloracne (EPA 2003). Secondary effects include dermal inflammation, irritation, hyperpigmentation, and hirsutism (also known as hypertrichosis, or abnormal distribution of hair). Noncarcinogenic effects associated with incidental ingestion of dioxins are more extensive and affect nearly every organ system. Predominant effects from incidental ingestion include changes in liver function and structure after exposure; these changes are demonstrated by an increased liver size and changes in hepatic enzyme levels. In addition, dioxins produce negative effects to the thyroid, kidney, neurological system, circulatory system, pulmonary system, and immune system, and development and reproduction of children (EPA 2003).

CDDs include 75 individual compounds, and the CDFs include 135 individual compounds. These individual compounds are technically referred to as congeners. Only 7 of the 75 congeners of CDDs are thought to have dioxin-like toxicity; these structures exhibit chlorine substitutions in, at least, the 2, 3, 7, and 8 positions. Only 10 of the 135 possible congeners of CDFs are thought to have dioxin-like toxicity; these structures also exhibit substitutions in the 2, 3, 7, and 8 positions.

A toxicity equivalency procedure was developed for risk analysis to describe the cumulative toxicity of these mixtures. This procedure involves assigning individual TEFs to the CDD and CDF congeners. TEFs are estimates of the toxicity of dioxin-like compounds relative to the toxicity of 2,3,7,8-TCDD, which is assigned a TEF of 1.0. TEF values for all other congeners are lower, ranging from 0.5 to 0.00001. Generally accepted TEF values for CDDs and CDFs are shown in the following table.

<b>ANALYTE</b>	<b>1989 EPA TEF</b>	<b>1998 WHO TEF</b>	<b>2005 WHO TEF</b>
1,2,3,4,6,7,8-HPCDD	0.01	0.01	0.01
1,2,3,4,6,7,8-HPCDF	0.01	0.01	0.01
1,2,3,4,7,8,9-HPCDF	0.01	0.01	0.01
1,2,3,4,7,8-HXCDD	0.1	0.1	0.1
1,2,3,4,7,8-HXCDF	0.1	0.1	0.1
1,2,3,6,7,8-HXCDD	0.1	0.1	0.1
1,2,3,6,7,8-HXCDF	0.1	0.1	0.1
1,2,3,7,8,9-HXCDD	0.1	0.1	0.1
1,2,3,7,8,9-HXCDF	0.1	0.1	0.1

ANALYTE	1989 EPA TEF	1998 WHO TEF	2005 WHO TEF
1,2,3,7,8-PECDD	0.5	1	1
1,2,3,7,8-PECDF	0.05	0.05	0.03
2,3,4,6,7,8-HXCDF	0.1	0.1	0.1
2,3,4,7,8-PECDF	0.5	0.5	0.3
2,3,7,8-TCDD	1	1	1
2,3,7,8-TCDF	0.1	0.1	0.1
OCDD	0.001	0.0001	0.0003
OCDF	0.001	0.0001	0.0003

Calculating the TEQ of a mixture involves multiplying the concentration of individual congeners by the TEF. The sum of the TEQ concentrations for the individual congeners is the TEQ concentration for the mixture.

Bioconcentration in aquatic organisms has been demonstrated. Mean bioconcentration factors (BCF) of 29,200 (dry weight) and 5,840 (wet weight) were measured for fathead minnows over a 28-day exposure; the elimination half-life after exposure was found to be 14.5 days. BCFs of approximately 1600 to 8,000 (unitless) were calculated for rainbow trout and fathead minnow in laboratory flow-through studies during 4 to 5 exposures. The following BCFs have been reported for various aquatic organisms: snails, fish (*Gambusia*), daphnia 20,000 to 25,000; duckweed, algae, catfish, 4,000 to 8,900.

### 5.2.3 Petroleum Hydrocarbons

Health effects from exposure to petroleum hydrocarbons depend on many factors (ATSDR 1999). These factors include the types of chemical compounds in the petroleum hydrocarbons, how long the exposure lasts, and the amount of the chemicals contacted. Very little is known about the toxicity of many petroleum hydrocarbon compounds. Until more information is available, information about health effects of petroleum hydrocarbons must be based on specific compounds or on data for petroleum products that have been studied.

The compounds in some petroleum hydrocarbon fractions can affect the blood, immune system, liver, spleen, kidneys, developing fetus, and lungs (ATSDR 1999). Certain petroleum hydrocarbon compounds can be irritating to the skin and eyes and can cause neurological affects consisting primarily of central nervous system depression. Other petroleum hydrocarbon compounds, such as some mineral oils, are not very toxic and are used in foods.

#### **5.2.4 Polycyclic Aromatic Hydrocarbons**

The toxicity of PAHs is generally expressed relative to the toxicity of benzo(a)pyrene. In addition to benzo(a)pyrene, six other PAHs are classified by EPA as probable human carcinogens. The six PAHs include benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-cd)-pyrene (EPA 1993). With the established carcinogenicity of benzo(a)pyrene, the other six compounds have been estimated to be 1 to 1,000 times less carcinogenic (EPA 1993). As a result, the general toxicological information presented in this section will be discussed for benzo(a)pyrene.

Benzo(a)pyrene is readily absorbed after inhalation, oral, and dermal routes of administration. After exposure through inhalation, benzo(a)pyrene is rapidly distributed to several tissues in rats. The metabolism of benzo(a)pyrene is complex and includes formation of a proposed ultimate carcinogen, benzo(a)pyrene-7,8-diol-9,10-epoxide. Dietary administration of doses of 10 mg/kg during gestation caused reduced fertility and reproductive capacity in mice offspring, and treatment by gavage with 120 mg/kg per day during gestation caused stillbirths, resorptions, and malformations (Risk Assessment Information System [RAIS] 2004). No data are available on the systemic (noncarcinogenic) effects of benzo(a)pyrene in humans.

Numerous epidemiologic studies have shown a clear association between exposures to various mixtures of PAHs containing benzo(a)pyrene (for example, coke oven emissions, roofing tar emissions, and cigarette smoke) and increased risk of lung cancer and other tumors. However, each of the mixtures also contained other potentially carcinogenic PAHs; therefore, it is not possible to evaluate the contribution of benzo(a)pyrene alone to the carcinogenicity of these mixtures.

PAHs can be accumulated in aquatic organisms from water, sediments, and food. In general, bioconcentration was greater for the higher molecular weight compounds than for the lower molecular weight compounds (EPA 2006a).

#### **5.2.5 Lead**

Human exposure to lead occurs primarily through diet, air, drinking water, dust, and paint chips. The efficiency of lead absorption depends on the route of exposure, age, and nutritional status. Adult humans ingest less lead than children, depending on the exposure medium (RAIS 2004). The systemic toxic effects of lead in humans have been well documented. The evidence shows that lead is a multi-targeted toxicant, causing effects in the gastrointestinal tract, hematopoietic system, cardiovascular system, central

and peripheral nervous systems, kidneys, immune system, and reproductive system. Lead can affect almost every organ and system in the human body. The most sensitive system is the central nervous system, particularly in children. Irreversible brain damage occurs at blood lead levels greater than or equal to 100 micrograms per deciliter ( $\mu\text{g}/\text{dL}$ ) in adults and at 80 to 100  $\mu\text{g}/\text{dL}$  in children; death can occur at the same blood levels in children. Children who survive these high levels of exposure suffer permanent, severe mental retardation. Lead also damages kidneys and the reproductive system. The effects are the same whether it is breathed or swallowed. At high levels, lead may decrease reaction time, cause weakness in fingers, wrists, or ankles, and possibly affect the memory. Lead may also cause anemia, a disorder of the blood (RAIS 2004).

EPA has evaluated inorganic lead and lead compounds for carcinogenicity. The data from human studies are inadequate for evaluating the potential carcinogenicity of lead. Data from animal studies, however, are sufficient based on numerous studies showing that lead induces renal tumors in experimental animals. A few studies have shown evidence for induction of tumors at other sites (cerebral gliomas; testicular, adrenal, prostate, pituitary, and thyroid tumors).

### **5.3 CONTAMINANT FATE AND TRANSPORT PROCESSES**

General fate and transport processes that may attenuate concentrations of contaminants present in groundwater include dispersion, dilution, sorption, volatilization, abiotic degradation, and biodegradation. These processes can be categorized into two groups: nondestructive attenuation mechanisms and destructive attenuation mechanisms. These attenuation mechanisms are discussed in the following sections, with emphasis on the fate and transport processes that are applicable at the KRY Site.

#### **5.3.1 Nondestructive Attenuation Mechanisms**

Nondestructive attenuation mechanisms result in decreasing aqueous contaminant concentrations, but no destruction of contaminant mass. These processes include sorption of contaminants to the aquifer matrix, dispersion or spreading of the contaminant mass in the aquifer during transport, dilution of the contaminant mass by mixing with unimpacted water, and volatilization of dissolved contaminants to soil vapor.

Sorption immobilizes contaminant mass by processes that fix or sorb compounds to the aquifer matrix. Organic carbon and clay minerals with large surface area-to-volume ratios generally act as sites of adsorption. Sorption slows or retards the contaminant mass relative to the bulk groundwater velocity. Sorption is quantified using the partitioning coefficient ( $K_d$ ) or retardation factor.

Dispersion describes the longitudinal and transverse spreading of the contaminant plume. Dispersion is caused by variations in flow velocity during advective transport of contaminants. Dispersion results in the three-dimensional mixing of the contaminants, but does not affect the total mass present in the plume. The dominant dispersion process in relatively fast-moving groundwater systems such as at KRY Site is mechanical mixing along tortuous flow paths in the aquifer matrix. Measurements of dispersivity are extremely difficult, and estimates are often based on plume length (Wiedemeir and others 1998).

Dilution of contaminant mass may occur along the flow path of plumes through infiltration of recharge from precipitation or recharge from the Stillwater River, resulting in dilution of contaminant concentrations along a flow path. Site-specific dilution rates of the contaminant mass have not been quantified at the KRY Site. In addition, dissolved chemicals leaching from contaminated vadose zone soils may be diluted by unimpacted groundwater underlying the contaminated soils.

Contaminant mass may volatilize across the water table, resulting in loss of contaminant mass to the vapor phase in the vadose zone. Volatilization of COPCs from groundwater and through the vadose zone can result in intrusion of COPCs from soil gas to subsurface structures and indoor air. The potential for vapor intrusion at the KRY Site is considered low based on comparison of groundwater chemical concentrations to EPA target concentrations for vapor intrusion (see Section 5.4.3 for additional discussion); however, a site-specific evaluation of vapor intrusion has not yet been conducted. The following subsections provide information on the nondestructive attenuation mechanisms applicable to PCP, dioxins and furans, petroleum hydrocarbons, PAHs, and lead.

#### **5.3.1.1 Pentachlorophenol**

The adsorption or mobility of PCP in soils is controlled primarily by soil pH. PCP is adsorbed to soil or sediment under acidic conditions, but the compound is mobile under neutral or alkaline conditions (Kuwatsuka and Igarashi 1975). The organic carbon partition coefficient ( $K_{oc}$ ) for PCP at a pH of 4.9 is 9,050 and at a pH of 8.0 is 410 (EPA 1996). The amount of PCP adsorbed at a given pH increases with increasing organic content of the soil (Chang and Choi 1974). PCP volatilization from an aqueous system is not considered a significant transport mechanism under ambient conditions (ASDTR 2001a).

Davis and others (1994) observed that retardation of the compound in the aquifer was greater at lower concentrations (below 40  $\mu\text{g/L}$ ) than at higher ones (above 1,000 or 10,000  $\mu\text{g/L}$ ), indicating that PCP will move at rates closer to that of the groundwater when present at higher concentrations (above 10,000

µg/L). The presence of cosolvents such as alcohols or petroleum hydrocarbons decreases the adsorption of PCP in soils by increasing its solubility in the soil solution (Christodoulatos and others 1994).

### **5.3.1.2 Dioxins and Furans**

Dioxins are physically removed from the atmosphere via wet deposition (scavenging by precipitation), particle dry deposition (gravitational settling of particles), and gas-phase dry deposition (sorption of dioxins in the vapor phase onto plant surfaces) (Rippen and Wesp 1993; Welschpausch and others 1995). Precipitation (rain, sleet, and snow) is very effective in removing particle-bound dioxins from the atmosphere (Hites and Harless 1991; Koester and Hites 1992). As air moves, photodegradation of the vapor-phase dioxins occurs and they are lost more readily than are the particulate-bound CDDs. Vapor-phase dioxins are not likely to be removed from the atmosphere by wet or dry deposition (Atkinson 1991), although deposition is a primary removal process for particulate-bound dioxins.

Adsorption is an important process affecting transport of hydrophobic compounds such as dioxins. The organic carbon fraction of the soil is believed to be the most important factor that governs the degree of adsorption of hydrophobic organic contaminants. Dioxins adsorb more strongly to soils with a higher organic carbon content than to soils with low organic carbon content (Yousefi and Walters 1987). Dioxins found below the surface soil (top few millimeters) are strongly adsorbed and show little vertical migration, particularly in soil with high organic carbon content, because of their very low water solubilities and vapor pressures (Yanders and others 1989).

Because they are only slightly soluble in water, dioxin may migrate in soil along with soil colloids and particles to which it may have been bound. Volatilization from soil surfaces during warm conditions may be a major removal mechanism (EPA 2006c). The persistence half-life of TCDD on soil surfaces exposed to sunlight and the atmosphere may vary from less than 1 year to 3 years, but half-lives below ground surface may be as long as 12 years.

### **5.3.1.3 Petroleum Hydrocarbons**

Petroleum products released to the environment migrate through soil via two general pathways: (1) as bulk oil flow infiltrating the soil under the forces of gravity and capillary action (bulk migration), and (2) as individual compounds separating from the bulk petroleum mixture and dissolving in air or water (compound migration).

## **Bulk Migration**

When bulk oil flow occurs, it results in little or no separation of the individual compounds from the product mixture, and the infiltration rate is usually fast relative to the dissolution rate (Eastcott and others 1989). Many compounds that are insoluble and immobile in water are soluble in bulk oil and will migrate along with the bulk oil flow. Factors that affect the rate of bulk oil infiltration include soil moisture content, vegetation, terrain, climate, rate of release, soil particle size, and oil viscosity. As bulk oil migrates through the soil column, a small amount of the product mass is retained by soil particles. The bulk product retained by the soil particles is known as “residual saturation.” Residual saturation can act as a continuing source of contamination as individual compounds separate from the bulk product and migrate independently in air or groundwater (Bauman 1988).

When the amount of product released to the environment is small relative to the volume of available soil, the downward migration of the bulk product may cease before it affects groundwater. Adverse impacts to groundwater may occur if rainwater infiltrates through soil that contains residual saturation and initiates the downward migration of individual compounds (ATSDR 1999).

Almost all motor and heating oils are less dense than water (Knox 1993; Mackay 1988). The downward migration of these products cease as water-saturated pore spaces are encountered. If the density of the bulk product is less than of water, the product tends to “float” along the interface between the saturated and unsaturated zones and spread horizontally in a pancake-like layer, usually in the direction of groundwater flow. In contrast, organic liquids with a density greater than water will continue to migrate downward through the water table aquifer under the influence of gravity. Downward migration ceases when the product is converted to residual saturation or when an impermeable surface is encountered. PCBs and other chlorinated organic solvents are usually denser than water. In reality, bulk oil flow is affected by numerous product-specific and site-specific factors. As a consequence, product distribution in the subsurface is typically heterogeneous and complex.

## **Compound Migration**

As the bulk product migrates through the soil column, individual compounds may separate from the mixture and migrate independently. Chemical transport properties such as volatility, solubility, and sorption potential are often used to evaluate and predict which compounds will likely separate from the mixture.

Since petroleum products are complex mixtures of hundreds of compounds, the compounds characterized by relatively high vapor pressures tend to volatilize and enter the vapor phase. The exact composition of these vapors depends on the composition of the original product (ATSDR 1999).

In general, compounds with a vapor pressure in excess of  $10^{-2}$  millimeters of mercury (mm Hg) are more likely to be present in the air phase than in the liquid phase. Conversely, compounds characterized by vapor pressures less than  $10^{-7}$  mm Hg are more likely to be associated with the liquid phase. Compounds that possess vapor pressures that are less than  $10^{-2}$  mm Hg, but greater than  $10^{-7}$  mm Hg, will tend to exist in both the air and the liquid phases (Knox 1993). Bossert and Bartha (1986) indicated that *n*-alkanes greater than C18 exhibit no substantial volatilization at ambient temperatures; however, lighter fractions (less than C18) are subject to volatilization. The rate of volatilization is also a function of air and soil temperature, humidity, wind speed, soil type, moisture content, oil composition, solar radiation, and thickness of the oil layer.

Solubility generally decreases with increasing molecular weight of the hydrocarbon compounds. For compounds having similar molecular weights, the aromatic hydrocarbons are more water soluble and mobile in water than the aliphatic hydrocarbons (ASTM 1995) and branched aliphatics are less water-soluble than straight-chained aliphatics. Coleman and others (1984) determined that the compounds most likely to be measured in water when in contact with gasoline, kerosene, and fuel oil #2 were the light-fraction, aromatic hydrocarbons such as benzene, toluene, ethylbenzene, and xylenes. These authors found that, although the aromatic compounds in these three fuels may represent as much as 50 percent by weight, aromatic compounds in the C6-C13 range made up approximately 95 percent of the compounds dissolved in water. This finding correlates well with studies that show an enrichment of light-fraction hydrocarbons in the water phase and depletion in the fuel phase.

Lighter petroleum products such as gasoline contain constituents with higher water solubility and volatility and lower sorption potential than do heavier petroleum products such as fuel oil. Data compiled from gasoline spills and laboratory studies indicate that these light-fraction hydrocarbons tend to migrate readily through soil, potentially threatening or affecting groundwater supplies. In contrast, petroleum products with heavier molecular weight constituents, such as fuel oil, are generally more persistent in soils because of their relatively low water solubility and volatility and high sorption capacity (Stelljes and Watkin 1991).

#### **5.3.1.4 Polycyclic Aromatic Hydrocarbons**

PAH compounds tend to be removed from the water column by binding to suspended particles or sediments, by volatilization to the atmosphere, or by being accumulated by or sorbed onto aquatic biota. Because of their low solubility and high affinity for organic carbon, PAHs in aquatic systems are primarily found sorbed to particles that either have settled to the bottom or are suspended in the water column. It has been estimated that two-thirds of PAHs in aquatic systems are associated with particles and that only about one-third are present in the dissolved form (Eisler 1987).

Sorption of PAHs to soil and sediments increases with increasing organic carbon content and with increasing surface area of the sorbent particles. Volatilization of acenaphthene, acenaphthylene, anthracene, fluorene, and phenanthrene (low molecular weight PAHs) from soil may be substantial (Coover and Sims 1987; Southworth 1979; Wild and Jones 1993). However, of 14 PAHs studied in two soils, volatilization was found to account for about 20 percent of the loss of 1-methylnaphthalene and 30 percent of the loss of naphthalene. Volatilization was not an important loss mechanism for anthracene, phenanthrene, fluoranthene, pyrene, chrysene, benz(a)anthracene, benzo(b)fluoranthene, dibenz(a,h)anthracene, benzo(a)pyrene, and indeno(1,2,3-c,d)pyrene (Park and others 1990).

PAHs have been detected in groundwater either as a result of migration directly from contaminated surface waters or through the soil (Ehrlich and others 1982; Wilson and others 1986). PAHs have also been shown to be transported laterally within contaminated aquifers (Ehrlich and others 1982).

#### **5.3.1.5 Lead**

When they are released to the atmosphere, lead particles are dispersed and ultimately removed from the atmosphere by wet or dry deposition. Approximately 40 to 70 percent of the deposition of lead is by wet fallout. Large particles, particularly with aerodynamic diameters of more than 2 microns, settle out of the atmosphere fairly rapidly and are deposited relatively close to emission sources; smaller particles may be transported thousands of kilometers (ATSDR 2005).

Lead tends to form compounds of low solubility with the major anions found in natural waters. The amount of lead dissolved in surface waters depends on the pH and the dissolved salt content of the water. The maximum solubility of lead in hard water is about 30 µg/L at pH above 5.4 and the maximum solubility of lead in soft water is approximately 500 µg/L at pH above 5.4 (EPA 1977). Hydroxide, carbonate, sulfide, and, more rarely, sulfate may act as solubility controls in precipitating lead from water.

At pH less than 5.4, the formation of lead sulfate limits the concentration of soluble lead in water, while at pH above 5.4, formation of lead carbonates limits the amount of soluble lead (EPA 1979b).

The speciation of lead in water also depends on the presence of other ligands in water. Lead is known to form strong complexes with humic acid and other organic matter (Denaix and others 2001; Gao and others 1999; Guibaud and others 2003). The adsorption of lead to organic matter, clay and mineral surfaces, and coprecipitation or sorption by hydrous iron and manganese oxides increases with increasing pH (Callahan and others 1979).

Nearly all forms of lead that are released to soil from anthropogenic sources, such as lead sulfate, lead carbonate, lead sulfide, lead hydroxide, lead chromate, and lead chlorobromide, are transformed by chemical and biotic processes to adsorbed forms in soil (Chaney and others 1988). The transformation process involves the formation of lead complexes with binding sites on clay minerals, humic acid and other organic matter, and hydrous iron oxides (Chaney and others 1988; Chuan and others 1996; Sauve and others 1997). The ability of soils to bind lead depends on the pH of the soil and the cation exchange capacity of the soil components (such as hydrous iron oxides on clay and organic matter) (Chaney and others 1988). Only a small fraction (0.1 to 1 percent) of lead appears to remain water-soluble in soil (Khan and Frankland 1983). The solubility of lead in soil depends on pH, being sparingly soluble at pH 8 and becoming more soluble as the pH approaches 5 (Chuan and others 1996). Between pH 5 and 3.3, large increases in the solubility of lead in soil are observed. These changes in the solubility of lead appear to correlate with the pH-dependent adsorption and dissolution of iron and manganese oxyhydroxides. In addition to pH, other factors that influence the solubility of lead in soil are total lead content and the concentrations of phosphate and carbonate in soils (Bradley and Cox 1988; Ge and others 2000; Pardo and others 1990; Sauve and others 1997).

### **5.3.2 Destructive Attenuation Mechanisms**

Destructive attenuation mechanisms of organic contaminants result in the removal of contaminant mass by biological and abiotic processes. Biological processes proceed by two broad mechanisms: (1) the use of the contaminant as a primary growth substrate by microorganisms, or (2) where contaminants are fortuitously degraded by cometabolism with another substrate without producing energy for the microorganism. Abiotic processes include hydrolysis where halogens are replaced by OH groups. Abiotic processes are not considered to be as important except in particular cases such as carbon tetrachloride and chlorinated ethanes such as trichloroethane (Wiedemeir and others 1998). The

following subsections provide information on the destructive attenuation mechanisms applicable to PCP, dioxins and furans, petroleum hydrocarbons, PAHs, and lead.

### **5.3.2.1 Pentachlorophenol**

Atmospheric PCP may be photolyzed in the absence of water, although mechanisms for this reaction are not well known (Crosby and Hamadad 1971; Gab and others 1975). Photolysis of sorbed or film-state PCP in the presence of oxygen has also been observed (Gab and others 1975). Based on estimated relative rates of photolysis and degradation by hydroxide radicals, it was concluded that photolysis would likely be the dominant of the two (ATSDR 2001a). Degradation products formed during photolysis include tetrachlorophenols, three tetrachlorodiols, and the quinones, chloranilic acid, and eventually 2,3-dichloromaleic acid, which also undergoes photolysis, but at a slightly slower rate than PCP. The final products from the complete photolytic degradation of PCP are carbon dioxide and chloride ions.

Pentachlorophenol is biotransformed in soils and groundwater by acclimated microorganisms. Hurst and others (1997) investigated the effect of soil gas oxygen concentrations on the biodegradation of PCP in soils. No statistically significant mineralization of PCP was measured at 0% oxygen concentrations. However, PCP biodegradation was indicated at oxygen concentrations as low as 2%, with a half life on the order of 50 days. Mohammed and others (1998) investigated PCP and phenanthrene biodegradation in a microcosm study of unfiltered aquifer samples (geologic material and groundwater) contaminated with PAHs and PCP. Although the concentration of the parent compound was reduced, only 1 percent of the applied radiolabeled PCP had mineralized by 56 days (Mohammed and others 1998). Neither nutrient addition nor sample sterilization had a significant effect on mineralization.

Reaction products from PCP biodegradation include pentachloroanisole; 2,3,4,5-, 2,3,4,6-, and 2,3,5,6-tetrachlorophenol; and 2,3,4-, 2,3,5-, 2,3,6-, 2,4,5-, 2,4,6-, and 3,4,5-trichlorophenol. The major products are 2,3,4,5-tetrachlorophenol and 2,3,6- and 2,4,6-trichlorophenol. The degradation products 3,4- and 3,5-dichlorophenol were also observed in biodegradation studies of PCP (Engelhardt and others 1986). These authors noted that pentachloroanisole was a major degradation product in aerobic soils, but was present in minor amounts in anaerobic soils. In anaerobic systems, PCP is biodegraded only through reductive dechlorination, and the degradation products 3,5-dichlorophenol and 3-monochlorophenol may accumulate. Complete dechlorination to phenol and its subsequent mineralization to methane and carbon dioxide have been observed (Frisbie and Nies 1997). In a review paper on microbial degradation of PCP, McAllister and others (1996) reported that the various intermediates found in numerous studies indicated

that microbial degradation of the compound occurs by different mechanisms that are associated with specific microbial consortia.

### **5.3.2.3 Dioxins and Furans**

The primary transformation reaction for CDDs and CDFs in the atmosphere depends on whether the CDD or CDF is in the vapor or particulate phase (EPA 2006c). Vapor-phase CDDs and CDFs are not likely to undergo reactions with atmospheric ozone, nitrate, or hydroperoxy radicals; however, reactions with OH radicals may be significant, particularly for the less-chlorinated congeners (Atkinson 1991).

Based on the photolysis lifetimes of dioxins in solution, it is expected that vapor-phase dioxins will also undergo photolysis in the atmosphere, although reactions with OH radicals will predominate. Particulate-bound dioxins are removed by wet or dry deposition with an atmospheric lifetime of 10 days (Atkinson 1991) and, to a lesser extent, by photolysis.

Photolysis is the major route of chlorinated dioxin disappearance in aqueous solutions (Hutzinger and others 1985). Although photolysis is a relatively slow process in water, chlorinated dioxins are rapidly photolyzed under certain conditions, (for example, when exposed to ultraviolet light of the appropriate wavelength and in the presence of an organic hydrogen donor). These hydrogen donors can be expected to be present in chlorophenol pesticides either as formulation solvents (such as xylene or petroleum hydrocarbons), as active constituents of the formulation (for example, the alkyl esters of 2,4-D and 2,4,5-T), or as natural organic films on soils (Crosby and others 1973). The photolytic behavior of chlorinated dioxins in an organic solvent or in a water-organic solvent, however, may not accurately reflect the photolytic behavior of these compounds in natural waters (Hutzinger and others 1985). In general, however, lower chlorinated dioxins are degraded faster than higher chlorinated congeners. Chlorine atoms in the lateral positions (for example, 2, 3, 7, 8) are also more susceptible to photolysis than are chlorine atoms in the para positions (such as 1, 4, 6, 9) (Choudhry and Hutzinger 1982; Crosby and others 1973; Hutzinger and others 1985).

Photolysis of 2,3,7,8-TCDD on soils is a relatively slow process compared with photolysis in an aqueous media (Kieatiwong and others 1990). Various biological screening studies have demonstrated that TCDD generally resists biodegradation.

### 5.3.2.3 Petroleum Hydrocarbons

Indigenous microbes found in many natural settings have been shown to be capable of degrading organic compounds. The final products of microbial degradation are carbon dioxide, water, and microbial biomass (ATSDR 1999).

The rate of petroleum hydrocarbon degradation depends on the chemical composition of the product released to the environment as well as site-specific environmental factors. Generally the straight chain hydrocarbons and the aromatics are degraded more readily than the highly branched aliphatic compounds (Havlicek 1988). The *n*-alkanes, *n*-alkyl aromatics, and the aromatics in the C10-C22 range are the most readily biodegradable; *n*-alkanes, *n*-alkyl aromatics. Aromatics in the C5-C9 range are biodegradable at low concentrations by some microorganisms, but are generally preferentially removed by volatilization and thus are unavailable in most environments. The *n*-alkanes in the C1-C4 ranges are biodegradable only by a narrow range of specialized hydrocarbon degraders. Finally, *n*-alkanes, *n*-alkyl aromatics, and aromatics above C22 are generally not available to degrading microorganisms.

A large proportion of the water-soluble fraction of the petroleum product may be degraded as the compounds go into solution. As a result, the remaining product may become enriched in the alicyclics, the highly branched aliphatics, and PAHs with many fused rings (ATSDR 1999).

Bacteria that decompose petroleum products use oxygen as an electron acceptor are important in the degradation process. The rate of biodegradation will depend, in part, on the supply of oxygen to the contaminated area, because aerobic metabolism is much faster than anaerobic metabolism. When there is an insufficient amount of dissolved oxygen available, organisms that can use other electron acceptors may degrade the contaminants but at slower rates (EPA 2006). The ideal pH range to promote biodegradation is close to neutral (6 to 8). For most species, the optimal pH is slightly alkaline, that is, greater than 7 (Dragun 1988). The moisture content of the contaminated soil will affect biodegradation of oils through dissolution of the residual compounds, dispersive actions, and the need for microbial metabolism to sustain high activity. The moisture content in soil affects microbial locomotion, solute diffusion, substrate supply, and the removal of metabolic by-products (ATSDR 1999).

Excessive moisture will limit the gaseous supply of oxygen for enhanced decomposition of petroleum hydrocarbons. Most studies indicate that optimum moisture content is within 50 to 70 percent of the water-holding capacity (Frankenberger 1992). Generally, as the temperature increases, biological activity tends to increase up to a temperature where enzyme denaturation occurs. The optimal temperature for

biodegradation to occur ranges from 18 °C to 30 °C. Minimum rates would be expected at 5 °C or lower (Frankenberger 1992).

At least 11 essential macronutrient and micronutrient elements must be present in the soil in proper amounts, forms, and ratios to sustain microbe growth (Dragun 1988). These 11 elements are nitrogen, phosphorus, potassium, sodium, sulfur, calcium, magnesium, iron, manganese, zinc, and copper. Nitrogen is usually the main limiting nutrient that governs the rate of decomposition of petroleum hydrocarbons. However, small amounts of phosphorus fertilizers may also be necessary to stimulate biodegradation (Mills and Frankenberger 1994).

The rate of biodegradation in soils is also affected by the volume of product released to the environment. At concentrations of 1 to 0.5 percent of oil by volume, the degradation rate in soil is independent of the concentrations of oil. However, as the concentration of oil rises, the first-order degradation rate decreases and the oil degradation half-life increases. Ultimately, biodegradation virtually ceases when the oil reaches saturation conditions in the soil (30 to 50 percent oil) (Eastcott and others 1989). Suarez and Rifai (1999) summarized measured field and laboratory biodegradation rates for petroleum hydrocarbons and chlorinated solvents in groundwater. Median benzene, toluene, ethylbenzene, and xylenes half-lives ranged from 17 to 231 days.

#### **5.3.2.4 Polycyclic Aromatic Hydrocarbons**

##### Atmosphere

The processes that transform and degrade PAHs in the atmosphere include photolysis and reaction with nitrogen oxide, nitric anhydride, hydroxyl radicals, ozone, sulfur dioxide, and peroxyacetyl nitrate (Baek and others 1991; NRC 1983). PAHs have a wide range of volatilities and therefore are distributed in the atmosphere between the gas and particle phases. The 24-ring PAHs exist, at least partially, in the gas phase (EPA 2006a).

Most PAHs in the atmosphere are associated with particulates (Baek and others. 1991). Two types of chemical reactions appear to be the predominant mode of transformation of these PAHs: (1) reactions between PAHs adsorbed on the particle surfaces and oxidant gases such as nitric oxide, ozone, and sulfite that do not appear to be influenced by exposure to ultraviolet irradiation; and (2) photooxidation of PAHs irradiated either under solar radiation or simulated sunlight which produces a variety of oxidized derivatives such as quinones, ketones, or acids (EPA 2006a). Kamens and others (1986) estimate that, even in highly polluted air, photolysis is the most important factor in the decay of particle-sorbed PAHs

in the atmosphere, followed by reaction with nitric oxide, nitric anhydride, and nitric acid. Degradation of PAHs on particle surfaces by ozone has been found to be an important pathway for their removal from the atmosphere (EPA 2006a).

### Water

The most important processes that contribute to degradation of PAHs in water are photooxidation, chemical oxidation, and biodegradation by aquatic microorganisms (Neff 1979). Hydrolysis is not considered an important degradation process for PAHs (Radding and others 1976). The rate and extent of photodegradation vary widely among the PAHs (Neff 1979). There is no easily defined trend in the rates of photolysis that could be correlated with the chemical structure of PAHs.

PAHs in water can be chemically oxidized by chlorination and ozonation. PAH degradation from chlorination has been reported by Harrison and others (1976a, 1976b). Pyrene was the most rapidly degraded PAH. Benzo(a)anthracene, benzo(a)pyrene, and perylene were also highly degraded. Indeno(1,2,3-c,d)pyrene and benzo(g,h,i)pyrene were intermediate with respect to relative degradation. Benzo(k)fluoranthene and fluoranthene were the most slowly degraded of the compounds tested. The PAH-related by-products that result from chlorination are not fully known (Neff 1979). Ozonation in water is generally slower and less efficient than chlorination in degrading PAHs (Neff 1979).

No correlation between biodegradability and molecular weight is evident in three- to four-ring PAHs. Concentrations of DO above 0.7 mg/L are adequate for biotransformation, and the presence of a minimal concentration of PAH is required for biodegradation to proceed (Borden and others 1989). The minimum total PAH concentration before biotransformation may be inhibited under ambient nutrient conditions may be 30 to 70 µg/L (Borden and others 1989).

### Soil

Environmental factors that may influence the rate of PAH degradation in soil include temperature, pH, oxygen concentration, PAH concentrations and the contamination history of the soil, soil type, moisture, nutrients, and other substances that may act as substrate co-metabolites (Sims and Overcash 1983). The size and composition of microbial populations in turn can be affected by these factors.

PAHs are usually divided into two groups based on their molecular weights.(Kanaly and Harayama, 2000). For example, reported half-lives in soil and sediment of the three-ring phenanthrene molecule may

range from 16 to 126 days while for the five-ring molecule benzo[a]pyrene they may range from 229 to 1,400 days (Shuttleworth and Cerniglia. 1995).

Studies on biodegradation of PAHs suggest that adsorption to the organic matter significantly reduces the bioavailability for microorganisms, and thus the biodegradability, of PAHs, including naphthalene (Heitzer et al. 1992; Weissenfels et al. 1992). There is considerable variability in reported naphthalene soil half-lives. The estimated half-life of naphthalene reported for a solid waste site was 3.6 months (Howard 1989). In less contaminated soils, more rapid biodegradation is expected to occur (Howard 1989). In soils with 0.2 to 0.6 percent organic carbon and 92 to 94 percent sand, the half-lives were 11 to 18 days (Klecka et al. 1990). In another study, sandy loams with 0.5 to 1 percent organic carbon had naphthalene half-lives of 2 to 3 days (Park et al. 1990). Biodegradation is accomplished through the action of aerobic microorganisms and declines sharply when soil conditions become anaerobic (Klecka et al. 1990).

Heitkamp and Cerniglia (1988) published the first study on the isolation of a bacterium from the environment that could extensively degrade PAHs containing four aromatic rings. Also, Mahaffey and others (1988) presented the first direct demonstration of ring fission during HMW PAH biodegradation. Mueller et al. in 1989 demonstrated for the first time that the utilization of a PAH containing four or more aromatic rings as a sole source of carbon and energy by bacteria is possible. They showed that a seven-member bacterial community isolated from creosote-contaminated soil was capable of utilizing fluoranthene. In addition, the community was capable of biotransforming other HMW PAHs in a concentration range of 0.3 to 2.3 mg/liter when grown on fluoranthene. During the ensuing decade, a diverse number of observations regarding the biodegradation of HMW PAHs by bacteria were published (Kanaly and Harayama, 2000).

Park and others (1990) measured PAH biodegradation rates in two soil types under aerobic conditions. Experimental results indicated half-lives ranged from 2 days (naphthalene) to 420 days (dibenz[a,h]anthracene). Coover and Sims (1987) documented a decrease in PAH biodegradation rates with decreasing soil temperature. Although there are differences in the biodegradation half-life values estimated by different investigators (Park and others 1990; Wild and Jones 1993; Symons and others 1988), their results suggest that the biodegradation half-lives of PAH with more than three rings will be considerably longer (more than 20 days to hundreds of days) than for the PAHs with three or fewer rings. Mean half-lives were found to be positively correlated with  $\log K_{ow}$  and inversely correlated with  $\log$  water solubility. Previous exposure of the test soils to PAHs enhanced the rate of biodegradation of low

molecular weight PAHs but had little effect on the loss of higher molecular weight compounds (Wild and Jones 1993).

### Sediment

Herbes and Schwall (1978) investigated the rates of microbial transformation of PAHs in freshwater sediments from both pristine and oil-contaminated streams. The authors found that turnover times in the uncontaminated sediment were 10 to 400 times greater than in contaminated sediment. Absolute rates of PAH transformation (micrograms of PAH per gram of sediment per hour) were 3,000 to 125,000 times greater in the contaminated sediment. Turnover times in the oil-contaminated sediment increased 30- to 100-fold per additional ring from naphthalene through benz(a)anthracene; naphthalene was broken down in hours, while the turnover times were about 400 days for benz(a)anthracene and more than 3.3 years for benz(a)pyrene. Therefore, four- and five-ring PAHs, including the carcinogenic benz(a)anthracene and benz(a)pyrene, may persist even in sediments that have received chronic PAH inputs.

The rate of biodegradation may be altered by the degree of contamination. At hazardous waste sites, half-lives may be longer since other contaminants at the site may be toxic to degrading microorganisms.

Bossert and Bartha (1986) reported reduced biodegradation of PAHs in soil containing a chemical toxic to microorganisms. Efrogmson and Alexander (1994) investigated the effects of NAPLs on the biodegradation of hydrophobic compounds, including phenanthrene, in soil and subsoil. Mineralization of phenanthrene in the subsoil was reduced if the compound was dissolved in a NAPL. However, the suppression of the mineralization of phenanthrene in soil by NAPLs was short-lived, suggesting growth of organisms capable of using phenanthrene.

## **5.4 CONCEPTUAL SITE MODEL**

The conceptual site model (CSM) is an integral part of the RI process. The CSM is the planning tool that organizes what is already known about the site and helps the planning team identify the additional information that must be gathered to make the decisions that will achieve the project's goals (EPA 2001). The CSM presents known and potential contaminant sources and contaminant release and migration mechanisms. The CSM also presents potential contaminant exposure pathways and routes and human and ecological receptors that are expected to be evaluated as part of the risk analysis. Use of the CSM is ongoing, and an iterative approach allowing the CSM to evolve and mature as site work progresses and data gaps are filled. Therefore, the CSM discussed below (Figure 5-1) is a draft compiled for the RI. A

more detailed conceptual site exposure model will be developed for use in the risk analysis to further refine exposure media, exposure routes, and receptor pathways.

#### **5.4.1 Primary Sources and Release Mechanisms**

The CSM contains several “primary sources” or locations thought to have directly received COPCs related to the KRY Site. At this time, the preliminary CSM contains known sources at the KPT, Reliance, and Yale Oil facilities. Primary sources of COPCs appear to be at the KPT and Reliance facilities with minor source concentrations at the Yale Oil facility. A removal action at the Yale Oil facility in 1993 (see Section 1.4.3) excavated and treated a large volume of source material. The source area at the Seaman Shelton site (near Northern Energy Propane) is not included in the CSM as it is considered a separate release of petroleum hydrocarbons unrelated to the activities at the KPT, Reliance and Yale Oil facilities. In addition, septic system drain fields have not been shown to be sources of contamination. Known and potential sources at each facility are summarized below:

##### **KPT Facility**

KPT is a former wood treating facility that operated from approximately 1945 to 1990. The facility encompasses 35 acres. Spills or leaks of wood treating oil that contained PCP from the treatment vats, piping, aboveground storage tanks (ASTs), and treated wood contaminated on-site soils and groundwater with PCP, dioxins and furans, PAHs, and diesel-range petroleum hydrocarbons. A removal action in 1999 (see Section 1.4.1) excavated some pentachlorophenol-contaminated soil and transported the soil to a hazardous waste landfill.

Leaking drums, a number of abandoned ASTs, and two maintenance shops associated with the Montana Mokko/Stillwater Forest Products and Klingler Lumber operations may have contributed minor amounts of petroleum contamination above screening levels in site soils at the KPT facility. However, sampling during the RI did not indicate that such contamination was widespread.

##### **Reliance Facility**

Reliance is a former oil refinery that operated from 1924 to the 1960s. The facility encompasses 7 acres. On-site disposal of sludge, leaks of sludge and oil from ASTs and piping and off-loading of crude oil contaminated soil with petroleum hydrocarbons and some metals, notably lead. Lead was found in surface soils above screening levels in the southern portion of the site. PCP was also found in soils above screening levels within the Reliance facility. Presence of PCP may have been the result of treated pole

storage in this area, although historic evidence of this is not well established. Groundwater beneath the Reliance facility is contaminated with petroleum hydrocarbons, PCP, dioxins and furans, and PAHs. A more detailed history of the Reliance facility is found in Section 1.4.2.

### **Yale Oil Facility**

The Yale Oil Facility is a former petroleum bulk plant and product refinery that operated from 1938 to 1978 (see Section 1.4.3 for more detailed history). The facility encompasses 2.3 acres. Leaks and possible spills from ASTs and piping contaminated on-site soils. Thermal desorption was conducted on the soils to remove petroleum hydrocarbon contamination; however some remaining soil is contaminated with petroleum hydrocarbons and PAHs. Elevated benzo(a)pyrene concentrations above the EPA Region 9 residential PRG were measured in five surface soil samples in the vicinity of the Yale Oil facility and two samples exceed the EPA Region 9 industrial PRG. Groundwater beneath the facility is contaminated with PCP, dioxins and furans, and petroleum hydrocarbons. Petroleum, PCP and dioxin and furan concentrations in groundwater are at or above human health standards and background levels.

### **5.4.2 Secondary Sources and Release Mechanisms**

In addition to the primary sources discussed above, the secondary sources (media that became contaminated as a result of the original releases) included in the CSM for the KRY Site are as follows.

#### **Soil**

The primary sources identified had the potential to contaminate surface soil and subsurface soil. Contaminants can be released from soil by volatilization and by leaching as precipitation infiltrates the soil. Contaminated soil is also potentially transported within or off the site by surface water runoff and wind-blown dust.

#### **NAPL**

Once spills or leaks or infiltration and percolation have occurred in source areas, NAPL may have formed, such that a discrete phase with its own physical properties may be present within the vadose zone or the shallow aquifer. LNAPL would be present as product floating on the water table or in residual saturation in the groundwater smear zone (the zone between the highest and lowest water table elevations). At this time, the presence of LNAPL has been confirmed at both the KPT and Reliance facilities; the presence of DNAPL has not been confirmed, but is not likely based on concentrations of

COPCs in deeper groundwater that are well below saturation limits and no evidence of DNAPL was encountered during soil boring and monitoring well construction. Contaminants can be released from NAPL by volatilization and through leaching when contacted by groundwater or infiltrating precipitation. LNAPL may also migrate horizontally and vertically in response to groundwater flow and fluctuations in the water table.

### **Dissolved Phase**

Low- to moderate-level contamination may have resulted from gradual infiltration and percolation and leaching from any of the primary sources, in addition to leaching from secondary soil and NAPL sources. Contaminants in the dissolved phase can migrate through soil to groundwater. Contaminants in the dissolved phase may migrate differently in the shallow aquifer at the KRY Site than in the NAPL phase.

### **5.4.3 Tertiary Sources and Release Mechanisms**

In addition to the primary and secondary sources discussed above, the tertiary sources (media that became contaminated as a result of the secondary source releases) included in the CSM for the KRY Site are as follows.

### **Groundwater**

Contamination is known to have migrated in groundwater to numerous wells within the KRY Site. Thus, this tertiary source has spread (low-level) contamination to domestic water users. Low-level PCP contamination was found in residential wells during the RI. Groundwater migration has transported contaminants horizontally through the upper unconfined aquifer to downgradient and off-site locations and vertically into the lower portion of the unconfined aquifer. Groundwater contamination was found during RI sampling in downgradient off-site wells and in some wells completed in the lower unconfined aquifer.

### **Surface Water and Sediments**

Contaminated soil carried by surface water runoff or contaminated groundwater (via aquifer transport) may migrate to the Stillwater River on the north side of the KRY Site and to the southeast of the site where groundwater data is limited. Low-level petroleum contamination was detected in river sediments adjacent to the KRY Site during RI sampling (Section 4.5). Contaminants were also found in sediments

upstream of the site, indicating that upstream sources are present. However, all sediment contaminants were measured at concentrations below sediment screening criteria.

### **Soil Gas**

Overlying air-filled soil pore spaces may become contaminated with vapors once subsurface soil and groundwater become contaminated. Some of the COPCs will preferentially migrate through soil gas. This phenomenon is a result of chemical and physical properties, including vapor pressure, that dictate that a vapor phase migrates upward, rather than remaining either bound to soil or staying dissolved in a saturated phase in the soil or capillary fringe of the aquifer. Therefore, soil gas becomes contaminated and, through volatilization, can be released to overlying air as a tertiary mechanism.

In particular, soil gas can find preferential migration pathways along utility lines in subsurface utility trenches. Thus, the subsurface soil along utility corridors is particularly vulnerable to collection and migration of soil gas. However, no soil gas sampling was conducted as part of the RI. Still, RI analytical results indicate the presence of low-level VOC contamination in KRY Site soils and groundwater. A comparison of groundwater chemical concentrations to EPA target concentrations based on vapor intrusion (see Table 4-1) indicates that the maximum concentrations of benzene, ethylbenzene, 1,2,4-trimethylbenzene, and 1,3,5-trimethylbenzene exceed target levels. Benzene and ethylbenzene only exceed criteria in wells associated with the Seaman Shelton area which is not considered part of the KRY Site. Additional evaluation of the vapor intrusion pathway may be appropriate.

#### **5.4.4 Pathways for Exposure**

If a source has been released to a site medium and receptors are exposed, then an exposure pathway is complete. Discussed below are the media-based pathways of potential concern for the KRY Site. Exposure pathways will be more thoroughly evaluated as part of the risk analysis.

### **Groundwater**

One of the primary media known to be contaminated at the KRY Site is groundwater. Therefore, all complete groundwater-related exposure pathways will be considered in the CSM and risk analysis.

### **Groundwater—Human Exposure**

Potential human exposure routes include ingestion (drinking water uses for residents and workers), inhalation (of vapors during showering or other uses), and dermal contact (during washing, bathing, and other uses) with contaminated shallow groundwater (and potentially vapor intrusion). In addition, a utility/construction worker may contact subsurface groundwater during dewatering or emergency repairs. Therefore, it will be important to consider exposures for a utility/construction worker in the risk analysis.

### **Groundwater –Ecological Exposure**

No ecological exposures to groundwater exist at the KRY Site; however, see the discussion below on surface water and sediment.

### **Surface Water and Sediment**

Results for surface water samples did not indicate the presence of elevated concentrations of site-related contaminants. River sediment has become contaminated through upstream, off-site releases, or overland (runoff) migration. However, concentrations of sediment contaminants were below sediment screening criteria. Until static water levels and stream gauging have been conducted for a year, the potential for contaminated groundwater to discharge to surface water should be retained as a potential exposure scenario. These media are being retained for further evaluation in the RI and risk analysis.

### **Surface Water and Sediment – Human Exposure**

Human exposure routes include ingestion and dermal exposures for recreational users accessing the Stillwater River.

### **Surface Water and Sediment – Ecological Exposure**

Ecological exposures may include sediment contamination in the Stillwater River; therefore, an aquatic assessment of direct contact (ingestion) exposures may be conducted for the appropriate aquatic food web. However, contamination in surface water has not been detected above biota-protective concentrations, as stated in DEQ-7 (DEQ 2006b).

Terrestrial ecological receptors (wildlife) would be expected to access the river, resulting in drinking water (ingestion) exposure. However, no elevated concentrations of contaminants were measured in surface water. Until static water levels and stream gauging have been conducted for a year, the potential

for contaminated groundwater to discharge to surface water should be retained as a potential exposure scenario.

## **Soils**

Existing data for soil indicate that surface soil (surface samples collected to 2 feet bgs) contamination is present at the KRY Site. Therefore, exposure pathways will be evaluated in the risk analysis for both surface soils (through aboveground spills and leaks) and subsurface soils (through subsurface leaks and leaching).

### **Soils – Human Exposure**

Future residential and current and future industrial and recreational exposures to source area surface soils via incidental ingestion, inhalation, and dermal contact are expected to be complete. In addition, a utility worker may contact subsurface soils both within and outside source areas that could be more contaminated (because of the physical and chemical properties of the COPCs) than would surface and near-surface soils. Therefore, it will be important to consider exposures for a utility/construction worker. RI sampling has shown that surface soil has been contaminated in areas some distance from the source areas, possibly as a result of the re-working of surface topography or the spread of contaminants throughout the site (including dust that migrates from site soils onto adjacent areas).

### **Soils – Ecological Exposure**

Ecological exposures to soils include ingestion (for wildlife) and direct contact (for plants and invertebrates). EPA normally considers two potentially complete exposure pathways to soil for birds and mammals: (1) incidental ingestion of soils during feeding, and grooming and preening; and (2) ingestion of food contaminated as a result of the uptake of soil contaminants. (See the biota section below.) Soil pathways included are soil particulate inhalation and dermal contact.

Inhalation of particulates will not be quantitatively evaluated since respirable particles (larger than 5 microns) are most likely ingested as a result of mucocilliary clearance (ingestion from respiratory tract to digestive tract) rather than being inhaled (Witschi and Last 1996, as cited in EPA 2000) and thus already accommodated in the soil ingestion pathway for ecological receptors. In addition, inhalation of contaminants associated with dust particles is expected to contribute less than 0.1 percent of total risk compared with oral exposures at equal exposure concentrations (EPA 2000). Therefore, inhalation of dust will not be evaluated in the risk analysis for the KRY Site.

Birds and mammals may also be exposed to contaminants in soils via dermal contact. However, current information is insufficient to evaluate dermal exposure for the contaminants in various soil matrices at the KRY Site, or to predict possible rates of absorption for many species. Dermal exposure is expected to contribute less than 1 percent to 11 percent of the total risk compared with oral exposures for most contaminants (EPA 2000).

## **Air**

As described above, soil and groundwater contamination can migrate from the surface soils (as particulates or vapors to be inhaled) or even from the subsurface (from vadose zone soils and the capillary fringe of underlying groundwater).

### **Air – Human Exposure**

Inhalation exposures (both indoor and outdoor vapors) are included in the CSM for future residential and utility workers, and for current and future industrial workers.

### **Air – Ecological Exposure**

The inhalation exposure pathway will not be considered for ecological receptors in the qualitative ecological risk analysis.

## **Vegetation**

Exposure through vegetation-related pathways is possible for many inorganic and organic contaminants that are known to accumulate in vegetation. Therefore, terrestrial vegetation-related pathways will be evaluated in the risk analysis.

Aquatic and wetland vegetation would similarly be expected to take up COPCs from sediment or ephemeral surface waters, although only 2,3,7,8-TCDD TEQ was measured in surface water above screening levels.

## **Biota**

Ultimately, biota that are directly exposed to contaminated media (such as earthworms that live in contaminated near-surface soils or invertebrates in sediment in the Stillwater River) may take up, or bioaccumulate, contaminants. This uptake can be important when contaminants transfer through the food

web to higher trophic level consumers, such as omnivorous mammals and birds that feed on the earthworms or to fish that consume invertebrates in sediment.

Biota-related pathways are included for the human recreational exposure (via biota [fish] ingestion) and ecological (terrestrial, aquatic, and wetland) receptors. However, further analysis of this pathway is not necessary for all compounds except dioxins and furans since there is no contamination in the river above screening levels. Dioxin and furan concentrations in surface water were found to be elevated and it may be appropriate to further evaluate exposure to this dioxins and furans via biota. However, the number of surface water dioxin and furan data is small (three samples) and additional sampling may be necessary to determine if further action is necessary.

#### **5.4.5 Human Receptors**

Specific receptors and scenarios are envisioned for the exposure pathways and routes described in Section 5.4.4 above to characterize the long-term (chronic) risks posed by contamination at the KRY Site, as described below. Exposure pathways will be more thoroughly evaluated as part of the risk analysis.

##### **Resident**

A “typical” resident (following the EPA Region 9-recommended default exposure assumptions set forth in the preliminary remediation goal background document; EPA 2004) is included in the CSM to visualize how KRY Site contamination might affect residents of Kalispell. The details of the conservative assumptions used in the residential exposure scenario will be described in the risk analysis.

##### **Industrial Worker**

A “typical” industrial worker is included in the CSM to visualize how the KRY Site contamination might affect industrial/commercial workers in Kalispell. This typical worker is defined following the EPA Region 9-recommended default exposure assumptions set forth in the preliminary remediation goal background document (EPA 2004) and with these default assumptions typically modified by DEQ based on climate. The details of the conservative assumptions used in the industrial worker exposure scenario will be described in the risk analysis.

### **Recreational User**

A recreational user (who might access soils and surface water bodies) scenario (sometimes called a “trespasser” or “site visitor” scenario) is also envisioned at the KRY Site. Following the lead of other EPA regions, many of the exposure assumptions will be adapted from existing supplemental guidance. However, this scenario will be site specific, at least in part, because the exposure assumptions developed for other regions may not reflect the climate- and location-specific needs of the Kalispell area.

### **Utility/Construction Worker**

A utility/construction worker (who might access subsurface soils and groundwater) scenario is also envisioned for use at the KRY Site. Exposure assumptions will be based on values provided in the EPA exposure factors handbook (EPA 1997) and other EPA guidance, as appropriate. However, this scenario will be site specific, at least in part, because the exposure assumptions developed for other areas may not reflect the location-specific needs of the Kalispell area (such as the site-specific soil depths where utilities are located and depth to groundwater). DEQ’s Tier 1 RBCA Guidance for Petroleum Releases (as found in DEQ’s VCRA Application Guide [DEQ 2002]) will be considered in this evaluation.

#### **5.4.6 Ecological Receptors**

As noted above, the results of the RI will be used to identify the media, and therefore, the ecological receptors, that are at risk of exposure. As noted above, ecological receptors conceptually included at this time include birds and mammals for ingestion of soils and sediments during grooming and preening, feeding, and for ingestion of food contaminated as a result of uptake of contaminants in soil and sediments. In addition, direct contact of plants and invertebrates in soil with contaminated surface soils may be evaluated in the risk analysis. Surface water contamination was not found above levels considered protective of biota; therefore, an aquatic food web (fish and piscivorous animals, including birds, mammals, and humans) may not be used to investigate food chain transfer.

#### **5.4.7 Risk Analysis Approach**

DEQ will be performing a risk analysis adopting the approach used for the Missoula White Pine & Sash Facility in Missoula, Montana, including a qualitative evaluation of ecological risks. A site-specific fate and transport evaluation will also be conducted using data gathered during the RI.

## **6.0 CONCLUSIONS AND RECOMMENDATIONS**

This section presents the conclusions of the RI performed at the KRY Site, identifies data gaps and recommendations to address the data gaps, and provides a brief description of the FS process.

### **6.1 CONCLUSIONS**

The objectives of the RI at the KRY Site were to adequately characterize the nature and extent of releases or threatened releases of hazardous or deleterious substances to allow the effective development and evaluation of alternative remedies, analysis of health and ecological risks, and development of cleanup levels. These objectives have generally been met; exceptions and data gaps are explained in this section, and recommendations are provided. The RI identified three primary sources of groundwater contamination within the site: the KPT facility source area, the Reliance facility source area, and the Yale source area. A fourth, off-site source area was identified at the Seaman Shelton site (near Northern Energy Propane). Portions of the groundwater within and downgradient of these sources contain chemicals at concentrations greater than both federal and state regulatory standards. Soil at the site contains chemicals at concentrations greater than both federal and state screening criteria. Primary sources of COPCs appear to be at the KPT and Reliance facilities with minor source concentrations at the Yale Oil facility. Chemicals and metals in surface water and sediment of the Stillwater River are at concentrations below federal and state screening criteria. Conclusions for the KRY Site RI program are described further in the following sections.

Concentrations of COPCs above commercial/industrial SSLs were reported in surface and subsurface soil samples collected from sample locations associated with source areas at the KPT, Reliance, and Yale Oil facilities. The vertical extent of soil contamination in some locations at the Reliance facility is not fully delineated; however, sampling during remedial design is proposed to fill this data gap (Section 6.2). However, the limits of soil contamination at all three source areas are considered adequately defined for analysis of risks and of remedial alternatives. With the exception of dioxins and furans and one sample located immediately north of the northeast corner of the KPT facility, no soil contamination at concentrations above residential SSLs was found in areas considered to have current residential use. Some samples from residential areas contained dioxin and furan concentrations slightly above residential screening criteria but below background concentrations. The approximate extent of surface soils with selected COPC concentrations above residential and commercial or industrial screening criteria is shown on Figure 6-1. The approximate extent of subsurface soils with selected COPC concentrations above residential and commercial or industrial screening criteria is shown on Figure 6-2.

The highest concentrations of PCP, dioxin and furan, and SVOCs in groundwater at the KRY Site have been reported in the portions of the plume within and downgradient of the KPT facility source area. In addition, lower level concentrations of PCP, dioxin and furan, and SVOCs in groundwater have been reported within the Reliance facility source area and downgradient of both the KPT facility and Reliance facility source areas. The extent of this contamination has generally been delineated by samples that did not contain COPCs at concentrations above laboratory detection limits. However, the eastern edge of groundwater contamination is not well delineated at intermediate and deep portions of the unconfined aquifer both upgradient and downgradient of well KRY129B, and installation of additional wells in that area is proposed (Section 6.2). In addition, PCP contamination was found in residential wells RW-12 and RW-1 at concentrations below human health standards. Resampling of these wells in October 2006 showed no detectable concentrations of PCP in these same wells. The reason for fluctuating PCP contamination in this area is not well understood and is considered a data gap.

The highest concentrations of petroleum contamination (EPH and VPH) at the KRY Site have been reported in portions of the plume within the KPT and Reliance facilities with lower concentrations within and around the Yale Oil facility. The extent of this contamination has generally been delineated by samples that did not contain COPCs at concentrations above laboratory detection limits. Petroleum contamination at the Northern Energy Propane (formerly Seaman Shelton) area is considered separate from, and unrelated to contamination at the KPT, Reliance, and Yale Oil facilities.

## **6.2 RECOMMENDATIONS**

Several data gaps have been identified after a review of all data collected during the RI. Additional work is recommended at the KRY Site and includes:

- Additional studies are recommended to optimize the enhancement and maximize denitrifying bacteria activity and the rates of hydrocarbon biodegradation.
- Quarterly monitoring of select residential wells is currently being conducted (RW-12 and RW-1) since pentachlorophenol contamination was identified in these wells during the RI.
- Monthly groundwater and surface water levels are being recorded to better define potentiometric surfaces and groundwater and surface water interaction throughout the year.
- The reason for the large vertical gradients between the well pairs at KRY125 and KRY129 is not known. Well completion in the varying geology may be responsible for the observed gradients. Ongoing monthly groundwater level data should be evaluated and may provide additional insight.

- Transportation and off-site disposal of contaminated materials from the KRY Site should require characteristic hazardous waste determination for ignitability, corrosivity, and reactivity.
- Dioxin and furan concentrations in surface water were found to be elevated. However, the number of surface water dioxin and furan data is small (three samples) and additional sampling is recommended to determine if further action is necessary.
- Three additional monitoring wells are recommended to define the horizontal extent of petroleum contamination in the Seaman Shelton area. Wells should be installed east, south, and west of monitoring wells NTL-MW-3 and NTL-MW-4.
- Additional sampling during remedial design is proposed at sampling locations within the southern half of the Reliance facility where the vertical extent of contamination is not fully defined. Subsurface sampling has adequately characterized elevated petroleum hydrocarbon contamination in this area to depths corresponding with the groundwater level smear zone (approximately 15 to 20 feet bgs) but little sampling occurred below these depths.
- One additional monitoring well completed in the lower portion of the unconfined aquifer is recommended to be installed downgradient of monitoring well KRY129B to define the limits of groundwater contamination in this area.
- One additional monitoring well completed in the lower portion of the unconfined aquifer is recommended to be installed north of the Reliance facility. It may be possible that there is PCP in the deeper portion of the aquifer underlying the residential areas north of the Reliance facility and with limited deep wells in the vicinity it is impossible to determine if there is a preferential flow pathway.
- Two additional monitoring wells completed in the intermediate portion of the unconfined aquifer (midway between the upper and lower portions of the unconfined aquifer) are recommended to be installed to define the concentrations of groundwater contamination at this depth in the aquifer. One of these wells is recommended to be located mid-way between monitoring wells KRY121B and KRY129B. One of these wells is recommended to be located mid-way between KRY121B and KRY111B. Sampling from these wells would more fully define the vertical and horizontal extent of PCP contamination in this area necessary to evaluate remedial options for this portion of the groundwater plume.

### **6.3 FEASIBILITY STUDY PROCESS**

After the site has been characterized in the RI process and risks have been evaluated, the FS is used to develop and evaluate remedial alternatives that can be used to remediate certain areas at a site that are identified as posing an unacceptable risk to human health or the environment. The development of remedial alternatives requires the following:

- (1) Identifying federal and state applicable or relevant environmental requirements, criteria, and limitations.
- (2) Identifying remedial action objectives.

- (3) Identifying potential treatment, resource recovery, and containment technologies that will satisfy these objectives.
- (4) Screening the technologies based on their effectiveness, implementability, and cost; and assembling technologies and their associated containment or disposal requirements into alternatives for the contaminated media at the site. These 3 criteria can be used as initial screening criteria for the large list of alternatives, but final screening must be done using the criteria in 75-10-721.

Typically, a range of remedial alternatives are developed during the FS process varying primarily in the extent they rely on long-term management of the site contamination. The upper bound of the range is an alternative that would eliminate the need for long-term management (including monitoring) at the site. The lower bound is an alternative that involves treatment as a principal element, but some long-term management of portions of the site that did not constitute “principal threats” would be required. Once potential alternatives have been developed, certain alternatives may be screened out to reduce the number of options that are analyzed in detail to minimize the resources dedicated to evaluating options that are less promising.

Treatability tests may be necessary during the FS to evaluate a particular technology on specific site contaminants should existing site data be insufficient to adequately evaluate remedial alternatives. Generally, treatability tests involve bench-scale testing to gather information to assess the feasibility of the technology.

Once sufficient data are available, remedial alternatives are evaluated in detail with respect to evaluation criteria that DEQ has developed to address the statutory requirements. The results of the detailed analysis are summarized and presented so that an appropriate remedy consistent with state requirements can be selected.

In general, the results of the FS then lead to the selection of a preferred remedy or remedies, preparation of a proposed plan, public comment, preparation of a record of decision document; development of the remedial design, and implementation of the remedial action.

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## **TABLES**

## **FIGURES**

**APPENDIX A**

**WESTERN RESEARCH INSTITUTE DATA**

**APPENDIX B**  
**FIELD LOGS**  
**(see enclosed CD)**

**APPENDIX C**  
**PHOTOGRAPHIC LOG**

**APPENDIX D**  
**MONITORING WELL AND BOREHOLE LOGS**

**APPENDIX E**  
**MONITORING WELL DEVELOPMENT LOGS**  
**AND SAMPLING DATA SHEETS**

**(see enclosed CD)**

**APPENDIX F**  
**GPS AND SURVEY LOCATION INFORMATION**  
**(see enclosed CD)**

## **APPENDIX G**

### **LABORATORY ANALYTICAL REPORTS AND RESULTS**

- RI data summary tables
- DEQ October 2006 residential well sampling data
- NTL sampling data included as hard copies.
- Other historic data sets and laboratory reports included in attached CD

**(see enclosed CD)**

**APPENDIX H**

**DATA QUALITY ASSESSMENT AND DATA VALIDATION REPORTS**

**(see enclosed CD for validation reports)**

**APPENDIX I**  
**AQUIFER TEST GRAPHICAL SOLUTIONS**