REMEDIAL INVESTIGATION FOR THE FORMER MAINTENANCE AND FUELING FACILITY IN SKYKOMISH, WASHINGTON

Prepared for

BURLINGTON NORTHERN RAILROAD
Overland Park, Kansas

Prepared by

REMEDIATION TECHNOLOGIES, INC.
Seattle, Washington

RETEC Project No. 3-1161-350

JANUARY 1996

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1.0 INTRODUCTION

This report presents the remedial investigation (RI) results for Burlington Northern Railroad's (BNRR) Former Maintenance and Fueling Facility located in Skykomish, Washington. The facility was historically used to refuel and maintain locomotives, provide electricity for electric engines, store snow removal equipment, and as a base of operations for local track repair and maintenance. Currently, facility use is limited to the latter two activities. The Site includes the former maintenance and fueling facility and adjacent properties that have been impacted by releases from the facility.

In 1993, BNRR entered into an Agreed Order (No. DE91TC-N213) with the Washington Department of Ecology (Ecology) to conduct a Remedial Investigation and Feasibility Study (RI/FS). This action was prompted by the discovery of petroleum-related products in soil and groundwater at the Site, and the presence of oily seeps to the South Fork of the Skykomish River. These discoveries were made during various phases of exploration performed from 1973 to 1992.

This document is submitted to Ecology as the Final Remedial Investigation Report for the Site. The RI was conducted in accordance with the work plan entitled *Burlington Northern Railroad Remedial Investigation/Feasibility Study Work Plan, Skykomish, Washington* (RI/FS Work Plan) (GeoEngineers, 1993) and the detailed field activities plan entitled *Sampling and Analysis Plan for the BNRR Maintenance and Fueling Facility, Skykomish, Washington* (SAP) (RETEC, 1993).

This report provides a description of field investigation methods, describes the conditions encountered, provides results of analytical testing and presents the conclusions developed under the RI. The purpose of the RI, a brief description of the Site background, and a summary of previous site investigations are presented below.

1.1 Purpose and Objectives

The purpose of the RI is to determine the nature and extent of contamination and assess potential risks to human health and the environment posed by the contamination. A separate feasibility study (FS) is being prepared to define and evaluate the feasibility of site cleanup alternatives. Together, the RI and FS will provide sufficient information to allow selection of a remedial action. Specific RI tasks and their objectives are:

- Explore the subsurface through boring and well installation to characterize the Site's subsurface stratigraphy.

- Collect and analyze soil samples from the surface and subsurface to evaluate the nature and extent of soil contamination.

- Install monitoring wells to characterize hydrogeologic conditions and identify the extent of free product and dissolved contaminants.

- Complete physical tests of soil samples and conduct slug tests to evaluate aquifer characteristics.

- Collect sediment and surface water samples from the creeks and river to evaluate impacts from the Site.

- Collect product samples for physical characterization and conduct product baildown tests to evaluate recoverability.

1.2 Site Background and Operating History

1.2.1 Site Description

The Site is located in the City of Skykomish, and includes the BNRR property and those areas impacted by activities performed at the facility. The general Site location and boundary are shown in Figure 1-1. The Site is located in the southern half of the southwest quarter and the southwest quarter of the southeast quarter of Section 26, Township 26 North, Range 11 East, (S½SW¼, Section 26, T26N, R11E and SW¼SE¼, Section 26, T26N, R11E), King County. The latitude and longitude of the Site are 47E42'36"N and 121E21'37"W, respectively. The areal extent of the Site is approximately 40 acres.

1.2.2 Operational History

The facility was originally owned and operated by the Great Northern Railroad (GNR). GNR owned the property from the late 1890s until 1970 when GNR merged with four other railroads and became BNRR. The facility is currently owned and operated by BNRR.

A detailed history of the facility is presented in the *Site History, Skykomish Maintenance and Fueling Facility, King County, Washington, Final Report* (Berryman, 1990). This report is included in Appendix B of the *Response to Ecology's Comments/Questions* (GeoEngineers, 1991b). The

facility has gone through five overlapping operational eras. Each era is discussed below in terms of the activities conducted and the products used during the era.

Coal and Steam Era

Steam produced by coal heat was used to power locomotives operating out of the facility during this era. Structures reportedly present during this time period included an engine house and turntable, sandhouse, blacksmith and machine shop, coal tower and chute, depot, and water tower. The engine house originally had nine stalls for repair work but, by 1902, only six stalls were being used. Each stall had a pit where a repair person could service the underside of a locomotive. Repair activities reportedly performed during this era included insulation of engine parts and boilers, cleaning and rebuilding seals, cleaning and repairing boilers, testing gauges, oil and degreasing, painting, and cleaning engine parts. The turntable was used to turn the locomotives around. The sand tower dispensed sand that the locomotives used for traction on steep grades. The machine and blacksmith shops were used to manufacture parts for repairs. Petroleum-related products reportedly used during this period included grease, lubricating oil, and fortnite oil (kerosene-like petroleum product used to clean parts).

Oil and Steam Era

Bunker C oil replaced coal as the heat source in steam locomotives in about 1908. The coal tower and chute were replaced by an oil unloading shed and sump and an aboveground oil storage tank. Bunker C oil was stored at the facility in below-grade wooden, concrete and steel sumps, and aboveground steel tanks. Fortnite oil was the only cleaning fluid reported to be used during this period. The depot was moved from the south side of the tracks to its present location north of the tracks on Railroad Avenue.

Electric Era

Construction of an 8-mile-long tunnel between Skykomish and Leavenworth and of an electric substation was completed in 1929. Electric-powered locomotives replaced Bunker C oil-powered locomotives through the tunnel to eliminate exhaust fumes. The facility became the transition point for Bunker C oil- to electric-powered locomotives.

The engine house was used for repairs on both road and helper engines until it was destroyed by a fire in 1943. However, evidence suggests that some elements of engine repair and maintenance continued at the facility through the mid-1950s.

Diesel Era

Diesel was used for locomotives traveling west of Skykomish as early as the mid-1940s and replaced both Bunker C oil and electricity. In 1956, installation of a tunnel ventilation system permitted diesel locomotives to operate within the tunnel and electric locomotives were abandoned. The diesel was stored at the facility in aboveground and underground storage tanks until 1974 when BNRR discontinued fuel handling activities at Skykomish.

Maintenance Era

Most engine repair and maintenance activities ceased in the mid-1950s. The electric substation building was used as a sandblasting facility for a period in the 1960s. BNRR discontinued all fueling operations at their Skykomish facility in 1974. At the same time, they also reportedly excavated and removed all known sources of petroleum product. The former structures of the facility are shown in Figure 1-3. The substation was demolished in August 1992. The depot building and maintenance building are the only structures remaining at the facility. Three sets of railroad tracks and at least four spur lines surrounded by railroad ballast and gravel comprise the remainder of the facility, which is currently used as a base of operations for track maintenance and snow removal crews.

1.2.3 Regulatory Background

A report of a potential problem associated with diesel fuel was found in the Washington State Pollution Control Commission Progress Report No. 14, dated December 1947. This report states:

> "Another recheck of the reported oil pollution of the Skykomish River at Skykomish showed there was some danger of the oil from the Railroad roundhouse dump being washed into Maloney Creek, from which it may make its way into the Skykomish River. The foreman of the roundhouse was contacted the condition pointed out, and he promised that immediate steps would be taken to correct the situation. He will build up the banks around the oil and refuse dump to a level that will prevent any spillages from entering the waters [of the] creek."

No initial or follow-up report was found in Ecology or BNRR records.

On June 22, 1973, Ecology responded to a complaint reporting black oil seeping into the Skykomish River adjacent to the bridge in the City. Their investigation found oil seeping from the south river bank. Ecology documented statements from area residents that oil had been seeping into the river for roughly 40 years. Information from Ecology files indicates the seeps may have

occurred as early as 1912. As a result of this investigation, BNRR was cited by Ecology with a Notice of Penalty. Ecology also notified EPA of the problems and EPA notified BNRR of their involvement in November 1973. BNRR paid a fine to Ecology and, in cooperation with Ecology, began remedial actions to eliminate further discharges to the river. BNRR encountered intense local opposition and a petition was submitted to the City calling for a halt to excavation along West River Drive. No more work was conducted along River Road.

A site hazard assessment (SHA) of the facility was completed by Ecology and Environment, Inc. (E&E) in June 1991 for Ecology. Compounds of concern were identified as total petroleum hydrocarbons (TPH), benzene, lead, polychlorinated biphenyls (PCBs), toluene and pyrene (E&E, 1991). Based on the SHA, Ecology assigned the Site a hazard ranking of one (1) using the Washington Ranking Method (WARM).

In a letter to Ecology dated April 1, 1991, BNRR indicated a desire to initiate an RI/FS in accordance with the Model Toxics Control Act Cleanup Regulation, Chapter 173-340 WAC (MTCA). On September 16, 1993, the Agreed Order to conduct the RI/FS was signed by BNRR and Ecology.

Under the Agreed Order, BNRR implemented an interim remedial action at the Site in addition to an RI/FS. The interim remedial action objective were to provide data to assess the effectiveness of product recovery for the FS and reduce the release of oily seeps to the Skykomish River. Ecology's approval on the *Interim Action Plan for the BNRR Former Maintenance and Fueling Facility* was received in October 1995 after a 30 day public comment period. Installation of the interim action was initiated in October 1995. Installation was completed and system startup was initiated in January 1996. Interim action activities will be briefly discussed in Section 9. Data collected during the interim action will be included in the report as appropriate.

1.2.4 Previous Investigations

BNRR, in cooperation with Ecology, excavated five test pits at the Site during August 1973 and installed three monitoring wells during June 1974. Further exploration or remediation efforts were not conducted during 1974 because of opposition from local residents (GeoEngineers, 1993). BNRR completed two voluntary phases of exploration and analytical testing at the Site from 1990 to 1992. Additionally, two underground storage tanks (USTs) were investigated and removed in October 1992. The results of these investigations and removals are documented in a Phase I Report (GeoEngineers, 1991a), a Phase 2 Report (GeoEngineers, 1992a), and *Report of Geoenvironmental Services: UST Removal* (GeoEngineers, 1992c); both reports were submitted to Ecology. The Phase

I and 2 investigations consisted of drilling 34 borings, installing 32 wells and excavating two (2) test pits. Soil samples were collected from the ground surface, borings and test pits, and groundwater samples were collected from the wells. Most of the wells were screened to intercept the water table interface to evaluate the presence of light non-aqueous phase liquid (LNAPL).

Soil samples were analyzed for at least one of the following: TPH; fuel hydrocarbons; benzene, toluene, ethylbenzene and xylene (BTEX); polynuclear aromatic hydrocarbons (PAH compounds); PCBs; and priority pollutant metals (PPMs). The compounds detected in soil were TPH, fuel hydrocarbons, PCBs and PPMs (primarily lead, arsenic and cadmium).

Groundwater samples were analyzed for at least one of the following: TPH, fuel hydrocarbons, BTEX, volatile organic compounds (VOC), semivolatile organic compounds (SVOC), PCBs and PPMs. The predominant compounds detected in groundwater samples were TPH and fuel hydrocarbons. BTEX, methylene chloride (a common laboratory contaminant), chloroform, 2-methylnaphthalene, phenanthrene, PCBs and PPMs were detected at either low concentrations or infrequently.

LNAPL was detected in several monitoring wells. LNAPL is believed to be present as the result of releases during historic fueling activities at the facility. LNAPL was observed in the former fueling area extending downgradient (northwest) to the South Fork of the Skykomish River.

The UST investigation involved collection of three samples of soils surrounding the USTs prior to tank removals and analysis for PCBs, total metals and TPH. Six samples were collected from excavation walls and base following the tank removals and analyzed for hydrocarbon identification and TPH. One soil sample from a test pit was also analyzed for TPH as diesel and gasoline.

1.3 Regulatory Authority

Ecology has the regulatory authority to identify, investigate and clean up facilities where hazardous substances are present under Chapter 70.105D RCW, Model Toxics Control Act MTCA. This Act is implemented through Chapter 173-340 WAC, the MTCA Cleanup Regulation. The Agreed Order signed by Ecology and BNRR describes how the RI/FS requirements under MTCA are to be implemented.

1.4 Scope of RI

The scope of the RI is described in detail in the RI/FS Work Plan (GeoEngineers, 1993) and the SAP (RETEC, 1993). The scope was a combination of research and field work. Research conducted for this RI included, but was not limited to determination of:

- demographics
- land use (property boundaries, zoning, utilities, structures)
- surficial features
- climatology
- natural and ecological resources

Field work conducted during this RI consisted of:

- drilling 21 borings
- constructing eight shallow and five deep monitoring wells in 13 of the borings
- drilling four borings with a hand auger
- collecting and analyzing 57 subsurface soil samples for at least one of the following parameters: total organic carbon (TOC), TPH, VOC, SVOC, PCBs, and/or metals
- collecting and analyzing 46 surface soil samples for at least one of the following parameters: TOC, TPH, VOC, SVOC, PCBs, and/or metals
- collecting and analyzing seven sediment samples for at least one of the following parameters: TOC, TPH, VOC, SVOC, PCBs, and/or metals
- conducting four quarters of groundwater sampling, (the number of groundwater samples collected per quarter ranged from 24 to 35) and analyzing for at least one of the following parameters: TPH, VOC, SVOC, PAH compounds, PCBs, and/or metals
- collecting and analyzing four product samples for surface tension, interfacial tension, viscosity and specific gravity
- conducting slug tests in four wells
- conducting product baildown tests in three wells

- collecting nine soil samples for permeability and grain size analysis

1.5 Report Organization

This report is organized in 14 sections, as follows:

- Section 1.0 provides an introduction, discusses the purpose and scope of the RI, and provides a description of the Site background and operational history.

- Section 2.0 discusses Site features including demography, land use, surficial features, climatology, and natural and ecological resources in the area.

- Section 3.0 presents the hazardous substance investigation, including identification and characterization of source areas and hazardous substances.

- Section 4.0 discusses methods of field investigation, including the rationale and procedures.

- Section 5.0 presents the soil investigation results, including the geology, soil quality data and a discussion of migration routes.

- Section 6.0 presents the groundwater investigation results, including the hydrogeology, groundwater quality data and a discussion of migration routes.

- Section 7.0 presents the surface water and sediment investigation results, including the surface water and sediment quality data, and a discussion of migration routes.

- Section 8.0 discusses the air quality investigation, including the regional air shed, air quality data, impacts and a discussion of migration routes.

- Section 9.0 discusses the interim action.

- Section 10.0 discusses regulatory classification and standards for waste and specific media.

- Section 11.0 presents the risk assessment.

- Section 12.0 discusses remedial goals and objectives.

- Section 13.0 presents data gaps, conclusions and recommendations
- Section 14.0 presents full citations for references presented in the text.

Appendices of investigation data and supporting information have been compiled to complement this report. A list of historic property owners and the results of a historic title search are contained in Appendix A. Appendix B provides water well logs for the City of Skykomish water wells, as well as other nearby wells. Appendix C contains logs for surface soil samples and wells and borings installed as part of this RI. Laboratory analytical reports and quality assurance/quality control (QA/QC) review of analytical data for soil and sediments are contained in Appendix D. Appendix E contains tabulations of previous soil and groundwater analytical data. Appendix F contains slug test recovery data. Appendix G contains groundwater contour maps, including those generated during previous investigations of the Site, whereas Appendix H contains RI-generated ground and surface water laboratory and QA/QC reports. Product analytical results are presented in Appendix I. Appendix J provides the modeling and estimation methods used to evaluate potential air quality impacts from the Site. Appendix K provides the laboratory analytical report for soil collected during the interim action.

2.0 SITE FEATURES INVESTIGATION

This section provides a description of the Site, defined as the former maintenance and fueling facility and the surrounding areas potentially impacted by former activities at the property. The regional Site setting is also discussed.

2.1 Demography

The City of Skykomish was founded in the late 1800s, primarily to support locomotive fueling and maintenance activities, and was incorporated in 1909. Data from the 1990 U.S. Census reports that the current population is 273. The median age is 34.4 years. The majority of the population is of German descent, followed by English, Irish, Scottish and French. The City experienced a limited growth rate of 2.7% between 1980 and 1990. Major employers of in area are the Skykomish School District and the U.S. Forest Service (U.S. Census, 1990).

2.2 Land Use

The City is considered a rural town and is surrounded by the Mt. Baker-Snoqualmie National Forest. Because of the topography and forest boundary, potential for expansion is limited. The surrounding area offers recreational opportunities such as fishing, hiking and skiing. The City is composed of public, commercial, industrial and residential properties. Figure 2-1 presents the current land use and zoning. The facility is an industrial facility, currently used as a base of operations for track maintenance and snow removal crews. Residential neighborhoods, small businesses and city property (City Hall, the public library, and public school) are located across Railroad Avenue north of the BNRR property (Hedges and Roth Engineering, 1992). Most businesses are located between Third and Sixth Streets.

Property ownership data are presented in Appendix A. BNRR is the current owner and operator of the facility. The property was owned by St. Paul-Minneapolis and Manitoba Railroad Company prior to 1899. The GNR owned and operated the facility between 1899 and 1970, when it merged with four other railroads to become BNRR. In the areas surrounding the facility, all but 69 of the property lots are residential. Forty-four of the nonresidential lots are owned by the City or the Skykomish School District. The remainder of the nonresidential lots are currently involved in nonindustrial activities. The historical property search indicates there have been 20 nonresidential

property owners from 1891 to the present in the vicinity of the Site. Past manufacturing activities in the northern portion of the Site have been limited to a brewery (1907), and a small millworks or cabinet making shop (1948 to 1956).

There is no public sewer system in Skykomish; rather, each building/house is serviced by its own septic system. The residents are served by two public supply water wells (Plate 1). Storm drains are located in the streets to direct surface water runoff to the river. Plate 1 shows existing and former structures and utilities in the vicinity of the Site.

2.3 Surficial Features

The City is at an elevation of about 930 feet above mean sea level (msl) and is located in the Skykomish River valley in the Cascade Mountains, about 35 miles from their western foot at Monroe.

The Skykomish River valley is narrow and steep-sided. The Site topography gently slopes northwest toward the river, as shown in Plate 2. The soil type at the Site is classified as Arents (USDA, 1992). These soils are moderately well to excessively drained. Runoff is slow and the hazard of water erosion for these soils is slight. On-site precipitation either quickly infiltrates the soil, or flows into storm drains and the former Maloney Creek channel which eventually drain to the river.

2.4 Climatology

Because of its geographic location, the Site receives a significant amount of precipitation. For example, the mean annual rainfall since 1988 for the Skykomish area is 111.1 inches. Average monthly rainfall for the period beginning January 1988 and ending July 1993 is graphed in Figure 2-2. Precipitation is highest between October and May. Snowfall during this period has averaged 58.4 inches per year; most of it falling between November and April, as shown in Figure 2-2. The maximum 2-year, 24-hour precipitation amount is 4.5 inches (Ecology, 1990).

Temperature data were obtained from the Western Regional Climactic Center (Figure 2-2). The average annual temperature in the Skykomish area is 49.4EF. The average annual daily temperature maximum is 57.7EF; the minimum is 41.0EF. The hottest month is August, with an

average daily high of 74.7EF and an average low of 52.7EF. January is the coldest month with a mean high of 39.9EF and a mean low of 30.8EF.

The closest weather station with wind speed and direction data is the Seattle-Tacoma Airport. Data from this station indicates that the average annual wind speed in the area is 8.7 miles per hour (mph). The predominant wind direction from 1984 to 1993 was south-southwesterly. However, the Site's location in an east-west trending river valley is likely the factor controlling wind conditions in the area. It is expected that winds at the Site would occur predominantly in the east-west direction.

2.5 Natural Resources and Ecology

2.5.1 Surface Water

The location of surface water bodies in the Site vicinity was included in Figure 1-2. The Site is located between the former Maloney Creek channel (former creek channel) to the south and the South Fork of the Skykomish River to the north. The former Maloney Creek channel is dry throughout much of the year. Maloney Creek is currently located southwest of the Site, and is a tributary of the South Fork of the Skykomish River, which flows to the west and joins the North Fork at Index. The Skykomish River is a tributary of the Snoqualmie River, which empties into Puget Sound at Everett.

The South Fork of the Skykomish River and its tributaries (Maloney Creek) is a Class AA waterway. According to WAC 173-210A-030, the characteristic uses shall include, but are not limited to:

(I) Water supply (domestic, industrial and agricultural)
(ii) Stock watering
(iii) Fish and Shellfish
(iv) Wildlife habitat
(v) Recreation (primary contact recreation, sport fishing, boating, and aesthetic enjoyment)

The water quality criteria for Class AA waterways is presented in WAC 173-210A-030(1)(c) and discussed in Section 12.

The United States Geological Survey (USGS) currently maintains one gauging station near the Site at Gold Bar. Gold Bar is located approximately 20 miles downstream of Skykomish. At this point, the Skykomish River drains a 535-square-mile area and discharge is much greater than that occurring at Skykomish. However, three gauging stations were previously maintained by the USGS in the immediate area that provide historical discharge data (USGS, 1993), which is more representative of river flow at Skykomish. Two stations are located on the Skykomish River; one is upgradient (east) of the confluence with the Beckler River (gauging station No. 1) and the other is approximately 10 miles downgradient of the Site, near the town of Index (gauging station No. 2). The third gauging station is located on the Beckler River (gauging station No. 3). The confluence of the Beckler and Skykomish rivers, is approximately 1 mile upstream from the Site (see Figure 1-1). Several streams flow into the South Fork of the Skykomish River between Skykomish and Index, including Miller River and Money Creek. Mean annual discharge of the Skykomish River at Index is roughly 50% greater than the combined discharge of the Beckler River and the South Fork upstream of the Beckler River. Therefore, river discharge at Skykomish is best represented by the combined discharge of the Beckler River and the South Fork, as measured at gauging stations Nos. 1 and 3.

Monthly discharge measurements for these two stations are available for a limited period of record as shown in Table 2-1 (USGS, 1984). The average annual discharge for these five years is roughly 1,350 cubic feet per second (cfs) and the maximum annual discharge was 1,700 cfs. Monthly average discharge trends are depicted in Figure 2-3. Discharge is greatest in April, May and June, in correspondence with springtime snowmelt and runoff. Low flow conditions occur in August, or late summer; high flow discharge is greater than 6 times low flow discharge. Annual peak flow at gauging stations Nos. 1 and 3 was available for a 21-year period spanning 1930 to 1931 and 1946 to 1970 (USGS, 1984). The maximum annual peak flow is 25,800 cubic feet per second (cfs) and the average annual peak flow is about 12,000 cfs. The drainage area upstream of the Skykomish River Bridge is 243 square miles (USGS, 1984).

The South Fork of the Skykomish River provides recreational opportunities such as rafting and fishing. Water rights information within 5 miles downstream of the Site were obtained from the Department of Ecology Water Resource Division. Two rights for surface water intakes were identified; both are located more than 3 miles downstream of Skykomish. The use classification for both rights is identified as commercial/industrial.

A King County Flood Boundary Work Map and a Flood Insurance Map (Harper Righellis, 1995 and FEMA, 1989) were obtained for the City of Skykomish. As shown in Figure 2-4, areas

within the 100-year flood plain include most of the area north of the railroad tracks and along Maloney Creek.

There are no designated wetland areas present at the Site. A City zoning map identified a small wetland area southwest of the Site, adjacent to Maloney Creek (Hedges & Roth Engineering, 1992). However, no wetlands were identified in the National Wetlands Inventory.

2.5.2 Groundwater

The aquifer underlying the Site and surrounding areas is used as a source of potable water. Groundwater in the area also recharges (i.e., discharges to) surface water. The residents of Skykomish are served by two public water supply wells that are located about 1,100 feet east (upgradient) of Skykomish city limits (Plate 1). The primary well is completed to a depth of 216 feet below ground surface (bgs) and is screened across three intervals between 181 and 216 feet bgs. A backup well is located adjacent to the primary well and is completed to a depth of 219 feet bgs. In addition to the public water supply wells, two additional wells are located within 1.5 miles of the Site. A well was installed north of the river in Sky River Estates development. The well was initially intended for water supply, but instead the development hooked up to the city of Skykomish system and the well was capped and is not used (per communication with Ted Cleveland). A second water well is located 1.5 miles east of Skykomish, and was drilled for Timberlane Village. Logs for area wells are provided in Appendix B. No confining units were observed in the logs for the city water supply wells. According to the logs, the formation consists primarily of sand and gravels, cemented at depth.

2.5.3 Plants and Animal Species

Skykomish is surrounded by the Mt. Baker-Snoqualmie National Forest, which supports a large variety of plant and animal species. The general distribution of vegetation in areas surrounding the Site is shown in Figure 2-5. Wooded areas are located south of town, north of U.S. Highway 2, and in small undisturbed areas between the South Fork Skykomish River and Highway 2 to the east. Riparian zones are located adjacent to Maloney Creek south of town and west of town between Highway 2 and the Old Cascade Highway on both sides of the Skykomish River.

The area of investigation is comprised of industrial, commercial and residential properties,. Therefore, the animal species commonly found in this area is primarily limited to animals that commonly cohabit with humans, such as squirrels, mice, crows, sparrows, song birds, etc.

An extensive search was conducted to identify the key wildlife species present in the vicinity of the Site. Two databases developed by the Washington Department of Wildlife were accessed to obtain this information:

- Nongame Heritage Database contains significant site observations of nongame species of concern, including federal- and state-listed species.

- Priority Habitats and Species is an inventory of key species use areas and key wildlife habitats, including the locations of federal- and state-listed species (threatened, endangered, sensitive, candidate) and other priority nongame and game species.

Data was compiled from these databases for an area encompassing 9 square miles around the Site.

The Nongame Heritage Database identified the following key species within a 9-square-mile area of the Site:

- Spotted Owl - state- and federally-endangered species
- Bald Eagle - state- and federally-threatened species
- Northern Goshawk - state and federal candidate species
- Marbled Murrelet - state- and federally-threatened

The Priority Habitats and Species database search resulted in the identification of two species located within the 9-square-mile search area:

- Harlequin Duck - a federal candidate species
- Mountain Goat

More information regarding ecological resources is presented in Section 11.4.1.

2.5.4 Aquatic Species

The Washington Rivers Information System, a state-wide inventory of all anadromous and resident fish distributions, identified both the South Fork of the Skykomish River and Maloney Creek in the vicinity of the Site as containing fish habitats. Immediately north of the Site, the river is classified as a critical spawning habitat for resident species. This reach of the river and its tributaries also contains anadromous fish runs and listed resident fish runs (Salmon (Chums, Humpies, Coho, Chinook and Sockeye), Cutthroat, Whitefish, Dolly Varden, Bull Trout and/or

Olympic Mud Minnow). Similarly, Maloney Creek is classified as a critical spawning habitat for resident species and contains anadromous and listed fish runs.

2.5.5 Sensitive Environments

Two areas within a 1-mile radius of the Site have been defined as sensitive environments. Both are identified as breeding areas for the Harlequin Duck. Specifically, these areas are:

1. the Beckler River and tributaries Harlequin Duck breeding area
2. the Skykomish River Harlequin Duck breeding area

Other sensitive environments located within the Skykomish and Grotto quadrangles, but outside of the 9-square-mile area, are the Money Creek Harlequin Duck breeding area and the north Skykomish Mountain Goat winter range.

3.0 HAZARDOUS SUBSTANCE INVESTIGATION

This section identifies the source areas at the facility based on operational history, and describes the products and hazardous substances used at the facility.

3.1 Source Areas

There are no active, operating sources of hazardous substances at the Site. Past releases from storage facilities and from former fueling and maintenance activities at the facility may serve as a source of contaminants. Three distinct areas can be defined on the basis of historical structures and known operations. These areas are the maintenance area, fueling area, and the substation and sandblasting area. Referring to the historical facilities and source areas shown in Figure 3-1, railcar and locomotive maintenance activities were conducted at the engine house, turntable, machine and boiler shop, and areas immediately east of these structures. Fueling operations were performed at the fueling stations, concrete oil unloader pits and oil pump house. Finally, transformer pads near the east substation were used to store electrical transformers, and in the 1960s the substation was used as a sandblasting facility. The specific activities performed within each source area and the products used are discussed below.

3.1.1 Maintenance Area

The eastern portion of the facility housed most of the repair and maintenance operations. The roundhouse (labeled as "engine house" in Figure 3-1), with its turntable to the east, was the primary service facility on the Site for steam locomotives during the coal and steam era (approximately 1890s to 1908). Each stall in the roundhouse had a work pit under it to enable a worker to repair or perform maintenance under the locomotive, or to allow for collection of liquids and spillage from the overhauling and maintenance work. The stalls were routinely washed out and cleaned. Other than grease and lubricating oil, the only other major product in use was fortnite oil. The 80-foot-diameter turntable was used to direct engines in and out of the roundhouse stalls and could connect with either of the incoming tracks (Berryman, 1990).

The machine and boiler shop was connected to the roundhouse on the west side, as shown in Figure 3-1. Activities conducted at the shop included metal work using presses, lathes, drills and shapers to construct new parts or repair items damaged during operations. A forge and emery wheel were also located in the building.

3.1.2 Fueling Area

Bunker C oil, diesel fuel, gasoline, fortnite oil and waste oil were used and stored at the facility, primarily within the fueling area in the northern portion of the facility. Bunker C oil was used during the oil and steam era through 1956, after which diesel locomotives were used exclusively. Tank cars brought the Bunker C oil onto the oil spur and under the roof of the oil unloading shed. Bunker C oil was reportedly heated to facilitate transfer into the 100,000-gallon tank shown in Figure 3-1 (Berryman, 1990). A wooden sump was used in this transfer process and was subsequently replaced by a concrete, then steel sump. Engines were fueled very near the oil tank.

Diesel fuel was used as early as the mid-1940s and later replaced both Bunker C oil and electricity. Diesel fueling activities occurred in the same area as prior Bunker C oil fueling (i.e., adjacent to the fueling stations and diesel tank). Diesel fuel was used until 1974 when BNRR discontinued fueling activities at the facility.

3.1.3 Substation Area

Upon electrification of the railroad line east of Skykomish in 1929, a new electrical substation was constructed at the facility (see Figure 3-1). The substation equipment at the Site was located in the southwestern portion of the facility and consisted of:

- one 8,000-KVA frequency set
- three 2,750-KVA-100KV-13KV transformers
- two 5,000-KVA-13.2-KV-44-KV transformers
- one switchboard

This equipment was removed in 1956 when GNR replaced electric- with diesel-powered locomotives. The only activity reported in the substation area after 1956 was use of the substation as a sandblasting facility.

3.2 Estimated Quantity

Petroleum products have been detected in soil and groundwater in the maintenance and fueling areas. There are no available operating records for the facility that could provide information regarding the volume of petroleum product used in fueling operations or maintenance activities over time. Also, there are no reports of releases or spills. Therefore, it is not possible to

estimate the quantity of petroleum product which may have been released to soils and groundwater at the facility.

PCBs have been detected in a few samples from the substation area at low levels (i.e., 0.11 µg/L in groundwater and 0.33 mg/kg in soil). Transformers associated with the substation area are the only conceivable source of PCBs previously detected. Because of the low levels of PCB observed, the transformers may have been non-PCB transformers (i.e., <50 ppm PCB) as defined by TSCA (40 CFR, Part 761). However, transformer oil contaminated with PCBs could have resulted in the observed PCB distribution. Although the number and size of transformers have been documented in historic records, information regarding oil composition and volume is not available.

Lead has been detected in shallow soils across the facility. Approximately 100 tons of sandblasting grit containing lead were removed from the former substation building in 1991 and disposed of at the Waste Management, Inc., landfill in Arlington, Oregon, according to hazardous waste manifest forms. GeoEngineers reported that sandblasting grit was evident in backfill material in a former gasoline UST excavation (1993). However, no records regarding this tank or excavation were found. This is the only information available regarding the quantity of sandblasting grit that may have been used at the facility.

3.3 Characteristics and Behavior of Petroleum Products and Hazardous Substances Used at the Site

The following sections describe the physical and chemical properties of the petroleum products (a hazardous substance under the Model Toxics Control Act (RCW 70.105D.020(5)(d))) and other hazardous substances used at the Skykomish facility. These other substances most notably include lead and PCBs. Also presented is information concerning toxicological effects of these products and constituents.

3.3.1 Diesel Fuel

The U.S. Chemical Substances Inventory (under TSCA) defines diesel oil as, "a complex combination of hydrocarbons produced by the distillation of crude oil, having carbon numbers predominantly in the range of C_9 to C_{20} and a boiling point range of 163E to 357EC." This definition encompasses both diesel fuel No. 1 (i.e., marine fuel, kerosene) and diesel fuel No. 2 (i.e., automotive or railroad diesel) (Millner, et al., 1992). Table 3-1 describes the principle chemical components of diesel fuel.

Diesel fuels are often erroneously characterized as containing large percentages of PAH compounds. The boiling point range of diesel fuel largely excludes the presence of benzene and PAH compounds (IARC, 1989) because the majority of carcinogenic PAH compounds distill at temperatures above that required to produce diesel fuel and middle distillates. However, there are minimal levels of PAH compounds and BTEX compounds due to the imperfect manufacturing processes (Griest, 1985).

PAH compounds are a group of unsaturated hydrocarbons having two to six molecular rings and are present in the environment from both natural and man-made sources. PAH compounds are found in crude oil as well as refined petroleum products and are common combustion by-products.

Sixteen individual PAH compounds have been listed as priority pollutants by EPA and standard EPA methods exist for their analysis. Table 3-2 summarizes the characteristics of the 16 compounds. For ease of discussion, the priority pollutant PAH compounds can be separated into two groups: low-molecular weight compounds and high-molecular weight compounds. The low-molecular weight PAH compounds are considerably more soluble in water and have lower organic carbon partition coefficients. This indicates that these compounds will be more mobile in the environment than the high-molecular weight PAH compounds. The low-molecular weight PAH compounds are: naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, and pyrene. High-molecular weight PAH compounds are: benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(123-cd)pyrene, dibenzo(ah)anthracene, and benzo(ghi)perylene.

Concern over PAH constituents is related primarily to the known or suspected carcinogenic PAH compounds. These compounds are all high-molecular weight compounds. The low-molecular weight PAH, such as naphthalene, have been shown to be non-carcinogenic and to exert low acute and chronic toxicity.

PAH compounds are subject to adsorption onto organic carbon in soils and sediments and are degraded and transformed by microbes. Processes such as photodecomposition, oxidation and hydrolysis of PAH compounds are not considered significant degradation pathways in soil system. In the aquatic environment, adsorption of PAH compounds onto organic-rich sediments is probably the dominant transport mechanism (Versar, 1979).

In addition to PAH compounds, petroleum products such as diesel fuel have the potential for containing BTEX and other aromatic compounds. Aromatic compounds, by definition, are fairly

volatile and often very mobile. However, due to their degradability, they are generally not persistent in the environment. Table 3-3 summarizes the characteristics of several volatile organic compounds.

3.3.2 Bunker C Fuels

The composition of Bunker C fuels is less consistent than that of diesel fuel. Bunker C represents a fuel mixture which generally contains both diesel-range (C_9 to less than C_{24}) and oil-range (C_{20} to greater than C_{32}) hydrocarbons. Two organizations provide chemical standards for Bunker C fuel oil: API and EPA. The API chemical standard weighs heavily in the motor oil range (C_{24} to C_{32}) and the EPA Bunker C chemical standard falls in the C_{12} to C_{24} (diesel) range. Generally, Bunker C fuels are prepared to provide a specific energy content (i.e., BTU value) rather than a specific mixture of diesel and oil-range hydrocarbons. Bunker C fuels are generally classified (for marketing and distribution purposes) based on BTU content and viscosity.

The toxicity of hydrocarbons is generally indirectly proportional to viscosity with products having high viscosity, such as heavy greases and oils, considered to have only limited toxicity (Klaassen, 1986). Bunker C fuels do have higher concentrations of PAH compounds than diesel fuels.

3.3.3 Polychlorinated Biphenyls

PCBs are a family of compounds that were widely used until recently in capacitors and transformers, as well as for other purposes. PCBs were desirable for these uses because of their thermal stability, water insolubility, insulation properties, and resistance to oxidation and chemical transformation. PCBs are highly hydrophobic, and therefore sorb strongly to solids and fats. Because of their stability and slow rate of biotransformation, they are retained in animal tissues, representing a long-term threat to higher trophic-level organisms (i.e., organisms at the upper levels of the food chain).

The most common trade name for commercial products containing PCBs is Aroclor (Monsanto Co.), and there are several Aroclors, denoted by a four-digit number indicating the type of molecule and the weight percent chlorine. There are 210 possible PCB compounds ("congeners"), with up to ten chlorine atoms per molecule, but many have not been found in industrial products. Nevertheless, any commercial product actually contains many different congeners; Aroclor 1254, for example, has up to 69 separate congeners (Hutzinger, et al., 1974).

There is extensive literature on the behavior of PCBs in the environment. Generally, these studies conclude that PCBs tend to sorb strongly to soil and do not migrate readily to groundwater or surface water. The more highly chlorinated isomers tend to adhere more strongly to the soil and they are also less soluble (Table 3-4). Mierure, et al. (1976) show that in general the lower chlorinated isomers are more soluble, more readily vaporized and biodegrade more rapidly than the highly chlorinated isomers.

3.3.4 Lead

Lead is a naturally occurring element and is a major constituent of more than 200 minerals. It exists in the environment in three oxidation states, 0, +2, and +4. Neither metallic lead nor the common lead minerals are soluble but they can be solubilized by some acids. Industrial lead products are sometimes more water soluble than natural lead. Lead has a tendency to sorb to solids (particularly clays) and to form complexes with natural organics (e.g., humic and fulvic acids).

The metabolism of inorganic lead, like that contained in sandblasting wastes from the Site, is closely related to that of calcium (Hodgson, 1987). As such, lead can be deposited in bones and teeth. Lead toxicity is in fact enhanced by deficiencies in calcium and iron (Klaassen, 1986).

4.0 FIELD INVESTIGATION

4.1 Field Investigation Rationale

As was discussed in Section 3.0, petroleum products, metals, and PCBs are present at the Site due to past releases from storage facilities and from fueling and maintenance activities. The results of previous investigations were used to develop the RI scope as detailed in the RI/FS Work Plan (GeoEngineers, 1993). The RI was designed to further characterize the nature and extent of contamination present at the Site. Specifically, the RI was intended to:

- further delineate the extent of metals, including lead, and PCBs in surface soils
- define the extent of LNAPL floating on the groundwater table and the extent of contaminants dissolved in the groundwater
- determine the distribution of metals, PCBs, and petroleum products (including VOC and SVOC) in subsurface soils, sediments and surface water
- characterize the geologic, hydrogeologic and hydraulic conditions that may affect contaminant fate and transport, and determine whether contaminants are being discharged off Site

The ultimate goal of these tasks is to estimate the areas and volumes of Site media that pose a potential risk to human health and the environment so that appropriate remedial action alternatives can be evaluated.

4.2 Field Investigation Procedures

The RI consisted of several field activities including:

- soil sampling to characterize the subsurface stratigraphy and to obtain samples for chemical and physical analysis
- well installation and sampling to characterize hydrogeologic conditions, identify the extent of LNAPL, and characterize groundwater quality

- sediment and surface water sampling in the nearby streams and river to obtain samples for chemical analysis

- sampling and testing to define the physical characteristics of the LNAPL product and to assess its recoverability

Unless noted otherwise, all field investigations were performed in accordance with the SAP (RETEC, 1993) and the project health and safety plan. The methods and procedures used for soil sampling, well construction and development, groundwater sampling, aquifer testing, and LNAPL testing are provided below. All sampling locations were surveyed as presented in Table 4-1.

4.2.1 Soil Sample Collection

Surface and subsurface soils were collected as part of the RI. Subsurface soils were collected from drilled borings or from hand augers. Surface soil samples were collected using a shovel. Surface soil and hand auger sample locations are shown in Figure 4-2. All sample locations were in accordance with the RI/FS Work Plan and SAP except for two hand auger locations which were adjusted due to access restrictions as discussed below.

Soil Sampling from Borings

Prior to drilling, the following utilities were contacted and notified of drilling plans: Sprint, Puget Power, and GTE. The BNRR Utility Locate group and the City were also notified. Sprint owns a major fiber optics cable located along the north shoulder of the Old Cascade Highway. The City utilities (water and storm sewer) are shown on Plate 1. No other utilities were located that would impact the proposed drilling locations.

Drilling services were provided by Cascade Drilling of Woodinville, Washington, in three phases. The initial phase was performed September 27–29, 1993, using a CME-75 hollow-stem auger drill rig. Out of the 11 borings attempted, five were abandoned due to refusal from coarse cobbles and boulders. Based on these problems, BNRR and Ecology decided that air rotary drilling methods would be more effective at accomplishing the investigation goals. Drilling continued using an Ingersoll-Rand T3W air rotary drilling rig from October 18–24, 1993. Fifteen wells and borings were installed during this second phase. An additional boring (B-12) was installed on October 29, 1993, to further define the southern extent of free phase LNAPL. Figure 4-1 shows the location of the RI and the previous wells and borings installed at the Site. Appendix C contains all logs for the surface soil samples, hand augers, borings and wells.

Soil samples were retrieved during drilling using a 2-inch-diameter split-spoon sampler 18 inches in length. Brass inserts were used to collect undisturbed soil samples for physical characterization. Soil samples were collected at 5-foot intervals during hollow-stem auger drilling for lithologic characterization and to screen the samples for evidence of contamination. During air rotary drilling, the lithology and field screening were determined on the cuttings discharged from the cyclone. All soil samples were classified according to the Unified Soil Classification System (USCS). Soil descriptions included the soil name, color, texture, grain size, consistency or compaction, and moisture content. Detailed boring logs with soil descriptions are contained in Appendix C. Field screening for evidence of contamination included visual and olfactory inspection (i.e., visible occluded oil, stained soils, characteristic odor, etc.). Organic vapor concentrations were also obtained for each soil sample using a photoionization detector (PID). The PID readings are included on the boring logs.

Three soil samples were collected from each boring for laboratory analysis. These samples were obtained from each of three soil/aquifer zones: 1) the vadose zone, 2) the saturated contaminated zone, and 3) the saturated clean zone. If there was no evidence of contamination, only two samples were collected. The vadose zone is defined as the unsaturated soils present above the groundwater table. The saturated contaminated zone is below the groundwater table interface and contains field evidence of contamination with petroleum product. Samples obtained for laboratory analysis from the vadose and saturated contaminated zones were the most contaminated soils from that zone as determined by field screening. The saturated clean zone is located below the water table and has no field evidence of contamination. Soil samples for laboratory analysis were removed from the split-spoon sampler, placed into glass jars, labeled, and placed directly on ice in a cooler for shipment to the laboratory.

Surface Soil Sampling

Surface soil samples were collected from 0-0.5 feet bgs at 45 different locations across the Site, as shown in Figure 4-2. These locations include all of the well and boring locations, locations labeled as "SS" (surface sample), and two background locations (BG). A decontaminated trowel, shovel or digging bar was used to loosen and remove the top 6 inches of the soil at the appropriate locations. A shovel was used to remove the soils from the sampling hole onto a clean sheet of visqueen. Soils were then transferred to clean sample jars which were subsequently placed directly on ice in a cooler. Soils were also placed into a plastic bag for headspace screening using a PID. Soil descriptions were recorded in the field notebook or the well or boring log and the remaining soils were returned to the hole. Soil descriptions are contained in Appendix C.

Hand Auger Sampling

Four hand auger samples were collected on privately owned property where drill rig access was constrained. Property owners were contacted prior to sampling, and written access agreements were obtained. Sampling locations HA-3 and HA-4 were moved to alternate locations with Ecology approval due to difficulty in getting the required access agreement at the original proposed locations.

Hand augers were advanced using a 6-inch-long, 4-inch-inner-diameter (ID) bucket attached to a 5-foot-long handle. Hand auger samples were collected by placing a clean sheet of visqueen over the sampling location, and cutting a hole in the center of the visqueen. The decontaminated hand auger was advanced through the hole, and, after each foot of advancement, the bucket was carefully removed from the borehole. Headspace and visual screening were performed on the removed soils. The hand auger was advanced to a total depth of 5 feet bgs or until refusal. Soil samples were selected for laboratory analysis from the most contaminated zone or, in the absence of visible contamination, from the deepest interval. Hand auger logs are presented in Appendix C.

Decontamination

All sampling equipment used in the soil investigation was decontaminated between samples to avoid cross-contamination. In addition, augers and casing were decontaminated between each boring to prevent cross-contamination. Soil cuttings produced during drilling were placed in Department of Transportation (DOT)-approved drums, labeled, and covered. These drums are currently stored on Site pending disposal (See Section 4.3).

Sample Handling and Laboratory Analysis

Soil samples selected for laboratory analysis were sent to ACZ Laboratories of Steamboat Springs, Colorado. Physical soil analyses were conducted by Pacific Testing Laboratories of Seattle, Washington. Samples were shipped for overnight delivery via Federal Express. Standard chain-of-custody documentation was maintained on all samples.

Table 4-2 provides a summary of soil samples collected and submitted for laboratory analysis, including the corresponding depth. Duplicate soil samples were collected as specified in the SAP and shown in Table 4-2. Duplicate split-spoon samples were collected by dividing the full length of the split-spoon into two samples. Duplicate surface soil and hand auger samples were obtained by transferring additional sample volume from the same depth interval into the sample jars.

4.2.2 Monitoring Well Installation and Development

Shallow monitoring wells were constructed in eight of the boreholes; these wells are identified as MW-33 through MW-40 in Figure 4-1. These shallow wells were designed to intercept the water table during all water level extremes to detect LNAPL, if present. Five deep monitoring wells were constructed during this investigation (identified as DW-1 through DW-5 in Figure 4-1). These deep wells were designed to characterize the vertical extent of groundwater contamination. The shallow and deep wells were also used to measure groundwater elevations in order to determine the directions and gradients of the groundwater flow.

All RI monitoring wells were installed in accordance with WAC 173-160, Minimum Standards for Construction and Maintenance of Wells, except where noted below. The wells were constructed of 2-inch-diameter Schedule 40 PVC casing and screen. The screen slot size for the wells was 0.010 inch. The shallow well screens consisted of 15-foot-long sections. In the deep wells, the well screens consisted of a 5-foot section placed between 40 and 45 feet bgs. DW-2 was screened between 38 and 42 feet bgs due to drilling refusal. The bottom of each well was capped with a flush-mount, threaded-end point.

The screen slot size of 0.020 inch proposed in the SAP was apparently overlooked and a 0.010 inch slot size was used in the well construction. This slot size was still appropriate for the sand pack used (10/20). The importance of a sand pack is to limit the amount of fines flowing into the well and the screen is to hold back the sand pack. Since the screen slot size was smaller these objectives were still met. This deviation has no impact on the RI results.

A filter pack of clean 10/20 Colorado silica sand was placed in the annular space around the screens. The filter pack extended a minimum of 1 foot above the top of the well screens. The use of a 1-foot sand extension above the top of the screen, in lieu of the 3-foot minimum specified in WAC 173-160 was approved by Rod Thompson of Ecology (Personal communication, 1993). The filter pack was designed to minimize the potential for fine-grained soils to enter the wells. A minimum 2-foot bentonite seal was placed immediately above the filter pack. The bentonite seal extended to within 2 feet of the ground surface. Concrete was placed from the top of the bentonite seal to the ground surface. A steel, locking, flush-mount well protector was cemented into place at the surface of all but two of the shallow wells (MW-39 and MW-40) and at two of the deep wells (DW-4 and DW-5). Aboveground well protectors with three guard posts were placed around the remaining wells (MW-39, MW-40, DW-1, DW-2 and DW-3). Well construction details are summarized in Table 4-3. Monitoring well logs are contained in Appendix C.

Following installation, wells were developed to restore the natural permeability of the formation adjacent to the borehole and to remove any contamination or formation damage that may have occurred during drilling. Well development commenced on November 1, 1993, and was complete by November 4, 1993, with the exception of MW-40. This well was developed after it was repaired (as discussed in Section 4.2.3, below) on November 8, 1993.

One of two methods were used to develop the newly installed wells. The first method involved surging and pumping using a QED well development pump. The second made use of a weighted polyethylene bailer for surging and a Wilden pneumatic double-diaphragm pump. The total volume to be removed during development, roughly 10 well volumes, was calculated based on the total well depth, depth to water, and casing diameter. Using either development procedure, wells were surged for about 15 minutes and approximately 30% of the required purge volume was pumped from the well. Specific conductivity, pH, and water temperature were measured periodically to ensure that conditions within the well had stabilized. Pumping continued until well conditions were stable, a particulate-free discharge was apparent, or until 10 well volumes were evacuated, whichever occurred later. Well development water was collected in barrels and transferred to a Baker tank for subsequent disposal. Decontamination of the pump and bailer was performed between each well according to the procedures outlined in the SAP (RETEC, 1993).

4.2.3 Well Repair

Throughout the course of the RI, various well repairs were performed as needed. These activities are summarized below.

During well development, it was discovered that MW-40 had developed a bulge in the casing just below ground surface, preventing the well from being developed or sampled. On November 8, 1993, Cascade Drilling removed the concrete well pad, replaced the well casing, and reset the well pad.

On February 23, 1994, well MW-35 was damaged by snow removal equipment. On March 3, 1994, Cascade Drilling mobilized to repair the well and noted that the cast iron well lid had been sheared off, and the well cap (thermos cap) had been knocked out of the well. A small amount of rain water or snowmelt had collected in the annulus of the well monument, but the water level had remained below the top of the casing. The well casing was intact and had not been damaged. The well was repaired by jackhammering out the asphalt pavement and the concrete well pad to a depth of 1 foot. A new flush-mount well protector was cemented into place and the well pad was completed.

On November 10, 1994, Cascade Drilling reset well MW-33. The well monument had risen a few inches above the pavement, creating a potential hazard to snow removal equipment. The concrete around the monument was removed, and the monument was reset flush with the pavement.

4.2.4 Groundwater Sample Collection and Elevation Measurements

Four quarters of groundwater sampling were completed during the RI. Wells were gauged in conjunction with quarterly groundwater sampling and during two separate gauging events. The following paragraphs describe well gauging and groundwater sampling procedures used for the investigation.

Groundwater Elevation Measurements

The well gauging procedures consisted of measuring the depth to water using an electronic water level indicator and evaluating the wells for LNAPL and DNAPL. In wells where LNAPL was suspected or known and drop tubes had not yet been installed, an oil/water interface probe was used to determine product thickness. Review of pre-RI gauging data identified difficulties in obtaining accurate product thickness and water level measurements due to product viscosity. To alleviate this problem, 1-inch drop tubes were placed in all existing wells containing LNAPL in June and July 1993. A drop tube was placed in new well MW-39 in 1994. To evaluate for the presence of DNAPL, a water level indicator was lowered to the total depth of the wells which contained a drop tube or no LNAPL. The presence of DNAPL would be identified by a stained probe. Wells which contain LNAPL could not be evaluated for DNAPL unless a drop tube had been installed because the probe became totally coated by the viscous LNAPL and the sensor would not work.

As per the SAP the wells were to be evaluated for DNAPL during each sampling event. It is not clear from the sampling notes that the wells were evaluated for DNAPL during each event. However, it is clear that the wells were evaluated for DNAPL during the first (November 1993) and second (April 1994) sampling rounds and no DNAPL was detected in any of the wells. All remedial investigation observations support this data, that DNAPL is not present at this site.

The use of the drop tubes allowed direct measurement of the piezometric surface using a water level indicator lowered into the tube. Since typical product thickness measurements were difficult, attempts were made to measure depth to the top of product using a steel tape and oil paste lowered in between the well casing (2-inch ID) and the drop tube. However, product was frequently reported above and below the water table. This is likely a function of product characteristics including viscosity and a specific gravity near 1.0. It is hypothesized that during water table

fluctuations, the highly viscous LNAPL simply smears and becomes adhered to the drop tube and well casing. Since space between the drop tube and well casing is limited to a 1-inch annulus, it was difficult to lower the measuring tape without contacting product adhered to the casing and drop tube before reaching the true top of product. Measurements to top of product may reflect this residual product level within the well, rather than the actual product level. All possible attempts were made to accurately estimate product thickness.

Groundwater Sampling

Groundwater samples were collected in November 1993, April 1994, August 1994 and November 1994. In addition to well gauging described above, dissolved oxygen (DO) and wellhead VOC were recorded prior to collection of groundwater samples. These data were recorded on the well gauging record. Groundwater quality samples were not collected from wells that contained a measurable thickness of LNAPL. The collection of LNAPL samples is described below in Section 4.2.7.

Monitoring wells without measurable LNAPL were purged prior to sample collection using a dedicated PVC bailer. Field measurements of pH, specific conductivity, and water temperature were taken to ensure stability of well conditions prior to sampling. Temperature and conductivity were measured using a YSI Model 33 S-C-T meter and pH was measured using an Orion pH meter. A minimum of three well volumes were purged from wells prior to sampling. Purge water was drummed (Section 4.3).

After purging, samples were transferred from the bailer to laboratory provided sample containers. A summary of the groundwater sampling and analysis performed during the RI is presented in Table 4-4. Standard chain-of-custody, labeling, preservation and sample handling techniques were used as detailed in the SAP (RETEC, 1993). Samples were shipped for overnight delivery to the laboratory via Federal Express. The laboratories used were ACZ Laboratories of Steamboat Springs, Colorado, and Analytical Resources, Inc. (ARI), of Seattle, Washington. QA/QC for groundwater sampling consisted of analyzing duplicate samples and field blanks, as summarized in Table 4-4.

Decontamination of groundwater sampling equipment was not necessary because dedicated bailers were used for sampling each monitoring well. The water level indicator and field meter probes were decontaminated between wells as per the SAP (RETEC, 1993).

4.2.5 Aquifer Slug Tests

Rising head slug tests were conducted in the following six wells: DW-1, DW-2, DW-4, MW-5, MW-36 and MW-40 on July 13 and 14, 1994. Well locations were selected to estimate and evaluate variability in hydraulic conductivity across the Site. Deep wells were tested in addition to shallow wells to provide information representative of deeper aquifer zones.

Static water level measurements were obtained from each well prior to beginning the test. Slug tests were performed by securing a pressure transducer connected to a data logger near the bottom of each well. A 1-inch-diameter and 7-foot-long slug (displacing approximately 0.30 gallon) was placed in each well. Each slug was lowered into the well using a clean, dedicated nylon rope and placed at shallow depth to avoid contact with the transducer. The water level was checked periodically and allowed to equilibrate to pretest conditions. The test was then initiated by starting the data logger and simultaneously removing the slug from the well. The data logger recorded water level changes using a preprogrammed standard logarithmic sampling interval. The test was stopped when the pre-existing water level was re-established. This procedure was repeated several times in each well. Recovery data were plotted as semi-log graphs for analysis. The best recovery data (i.e., most data points and best-fit line) from each well were analyzed using Geraghty & Miller's AQTESOLV program to estimate hydraulic conductivity. Well MW-40 did not contain enough water to fully cover the slug, so data from this well was not analyzed.

4.2.6 Surface Water and Sediment Sample Collection

Four quarters of surface water sampling were conducted during the RI as summarized in Table 4-4. Surface water samples were collected in conjunction with each of the quarterly groundwater sampling events. The sampling locations were in Maloney Creek, the Skykomish River, and the former creek channel, as shown in Figure 4-2. Samples were collected in the deepest part of the stream, where possible. Prior to sampling, the pH, specific conductivity, temperature, and DO were measured by placing probes directly into the water. Once readings were obtained, water samples were collected by placing the sample bottle in the stream with the mouth of the sample bottle 1 to 2 inches below the surface. Samples were submitted to ACZ Laboratories for analysis in accordance with the program outlined in Table 4-4.

Stream sediment samples were collected from seven locations on October 7, 1993. The sampling locations were marked with a stake and later surveyed, and a description was made of the general area (see Table 4-1 for survey results). A decontaminated trowel was used to remove sediments from the sampling location to a clean piece of visqueen. A sediment sample was also placed into a plastic bag for headspace analysis with the PID; screening data and sediment descriptions were recorded in a log book and are provided in Appendix C. The laboratory samples

were prepared by placing the sediment into clean sample jars. The remaining sediments were returned to the hole. Samples were submitted for analysis as shown in Table 4-2. Decontamination of all sediment sampling equipment was performed between all sample locations to prevent cross contamination.

4.2.7 Product Sampling and Baildown Testing

Product Sample Collection

Samples of the LNAPL product were collected from three wells (MW-22, MW-27, and MW-39) and from a product seep along the south bank of the river (near sediment sampling locations SED-4 and SED-5). The three wells were selected for sampling because they have historically contained the greatest accumulations of LNAPL, or because they would provide data on the variability of visibly different types of LNAPL. For example, well MW-39 contains LNAPL which is darker and visibly more viscous than observed elsewhere at the Site, and therefore, it was deemed important to evaluate this well separately.

Product samples were collected from wells using dedicated PVC bailers. The product sample from the river bank was collected by submerging the bottle in the water and allowing the product to flow into the bottle.

Product samples were submitted for analysis of surface tension, interfacial tension, specific gravity, and viscosity to Hauser Laboratories, Inc., of Boulder, Colorado. Chemical analysis of the product using WTPH-HCID (hydrocarbon identification analysis) was performed by ACZ Laboratories.

Product Baildown Tests

Product baildown tests were performed to confirm the continuous presence of free product in the formation outside of the test well, and to evaluate product recoverability. Product baildown tests were performed on wells MW-17, MW-20, and MW-27 on April 28, 1994. These wells have consistently contained accumulations of LNAPL over time. The test procedure is outlined in detail in the SAP (RETEC, 1993). The basic steps include measurement of static depths to product and water, bailing product from the well, and monitoring depth to product and water during recovery of LNAPL flow into the well.

Due to the high viscosity of the product, accurate thickness measurements were difficult to collect. Product thicknesses were estimated using a bailer. Because of the difficulty in obtaining a quick and accurate depth to water and product thickness measurements, the baildown test was modified so that only the depth to product was measured. Under the modified test procedures, the depth to product was measured and then a decontaminated stainless steel bailer was used to quickly remove product. The depth to product was then monitored until the product returned to the pretest level or adequate recovery data had been obtained.

4.3 Management of Investigation-derived Wastes

Soils produced during drilling operations were placed into 55-gallon drums. Drums were labeled with the date, well number, drum number and waste matrix. A total of 60 drums were used. These drums are currently stored east of well MW-16. A composite sample of drum contents was collected on December 28, 1993, and analyzed for the following parameters in order to determine disposal options:

- metals, VOC and SVOC analysis of TCLP extract (extraction by EPA Method 1311)
- halogenated hydrocarbons and PAH for compliance with Dangerous Waste Regulations
- ignitability by EPA Method 1010
- corrosivity (pH) by EPA Methods 9040 and 9045
- PCBs by EPA Method 8080

Water produced during well installation, development, purging and decontamination was collected initially in drums. Due to the large volumes of water produced, a 4,000-gallon Baker tank was used to collect water generated during the October and November 1993 RI work. The water was characterized and disposed of by Marine Vacuum Services, Inc., of Seattle, Washington.

Purge water collected during subsequent sampling rounds is stored in 55-gallon drums on Site. Nine drums containing purge water are currently stored near MW-16.

5.0 SOIL INVESTIGATION RESULTS

The soils portion of the RI was conducted to further characterize the subsurface conditions at the Site. This effort focused on evaluating the vertical and horizontal distribution, and nature of contamination and the local stratigraphy through soil sampling and analysis. A discussion of the local and regional geology of the Site vicinity is followed by a presentation of the soil analytical and physical testing results.

5.1 Geological Setting

The bedrock geology in the Cascade Mountains is complex, with multiple episodes of deposition and faulting. About 5 miles to the east of Skykomish is the Straight Creek Fault, which generally divides unmetamorphosed and low-grade metamorphic oceanic rocks to the west from medium- to high-grade metamorphic continental rocks to the east. The major movement on this fault was concluded by middle Eocene time (c. 45 million years Before Present [B.P.]). This fault can be traced from the Yakima area north into British Columbia.

The oceanic rocks to the west of the Straight Creek Fault generally consist of metamorphosed oceanic sediments. These rocks consist of accretionary melanges, pillow basalt, limestone, chert, and other oceanic sediments. These rocks were metamorphosed to phyllite, greenstone, greenschist, blueschist, and marble.

The continental rocks to the east of the Straight Creek Fault mostly consist of schist. These rocks make up a distinctive part of the North Cascades crystalline core. The schist was metamorphosed from a thick sequence of sandy to silty sedimentary rocks. The age of formation of these rocks is likely Triassic or Jurassic, with a metamorphic age of late Cretaceous.

A generalized geologic map of the area around Skykomish is presented in Figure 5-1. The oldest rocks exposed in the vicinity of Skykomish consist of small exposures of phyllite and greenschist of the Easton terrain. These rocks are moderately metamorphosed oceanic sediments and volcanic rocks and are interpreted to have been formed in Jurassic time with an early Cretaceous age of metamorphism (c. 130 million years B.P.). Overlying these rocks, in apparent unconformable contact, are volcanics of the Barlow Pass Formation. This unit consists of a thick pile of altered basalt, andesite, and rhyolite, with distinctive sandstone interbeds (Tabor, et al., 1993).

Intruded into the metamorphic rocks in the area of Skykomish is the Grotto batholith. These igneous rocks have been dated at about 25 million years B.P. (Oligocene/Miocene). The intrusion of these rocks has resulted in a distinctive metamorphic overprint to the surrounding rocks. The igneous intrusions and secondary effects have resulted in several mining districts in the area, notably the Index, Monte Cristo and Silver Creek mining districts. Minerals are mined for gold, silver, copper, lead, and zinc.

The Cascade Mountain Range rose in late Miocene and Pliocene times. A broad, roughly even surface along the present-day ridge crests in the area of Skykomish suggests the formation of a former mature erosional surface which predated the uplift of the Cascades. Valleys are excavated within belts of erosional weak rocks which generally trend to the northwest.

During glaciation of the region between 19,000 and 13,000 years ago, large alpine glaciers moved down the river valleys towards Puget Sound, resulting in glacially carved valleys. These glaciers resulted in long, straight valleys and steep, U-shaped valley walls.

Several individual landslide deposits are present. Slide deposits consist of nonsorted nonstratified sediments. A large landslide deposit (about 1 square mile in area) is located immediately southeast of the Site, beyond the turnaround, as shown in Figure 5-1. The age of this slide is thought to be between 3,400 and 450 years old.

The valley floor at Skykomish consists of alluvial deposits comprised of coarse, angular boulder-gravel deposits.

5.2 Local Geology

Local stratigraphic conditions were evaluated during the installation of monitoring wells and borings. In general, the Site is underlain by sand and gravel, with silt and clay lenses. The silt and clay lenses are discontinuous and therefore do not comprise an aquiclude. The sand and gravel are derived from erosion of igneous and metamorphic rocks in the Cascade range and deposited by the river and Maloney Creek.

The distribution and extent of lithologic units observed across the Site are presented in two cross-sections. The cross-sections are located as shown in Figure 5-2. Cross section A-A' (Figure 5-3) runs across the entire facility, parallel to the railroad tracks. Cross section B-B' (Figure 5-4) bisects the Site, extending southeast from the river to beyond the former Maloney Creek channel.

Topsoil material up to 4 feet thick is evident at isolated locations across the Site. The topsoil is loose to medium-dense and consists of gravelly or silty sand with trace organics. Underlying the topsoil, native soils consist primarily of sand and gravelly sand and extend to depths of at least 50 feet bgs (corresponding to total depth of deep borings). The sand is generally medium- to coarse-grained and fairly dense. Gravels were generally as large as 1 foot in diameter; however, during drilling, gravels up to 3 feet in diameter were occasionally encountered. Bedrock was not encountered during drilling.

Discontinuous silt lenses consisted of brown or gray clayey silt or sandy silt and were medium-stiff, very-stiff or hard. The clay lenses are comprised of brown or gray silty clay with some sand. In most cases, these lenses appear to be fairly thin or less than 3 feet thick. However, a fairly large fine grained deposit occurs in the center of the Site which appears to correlate across at least three borings (MW-37, MW-20 and MW-8). This lens is at least 12 feet thick and extends about 300 feet horizontally.

5.3 Soil Quality Data

Soils were sampled for chemical analysis from the ground surface and at depth at several locations throughout the study area (refer to Figures 4-1 and 4-2 for locations). Subsurface samples were obtained from boreholes during drilling and via hand auger as discussed in Section 4.2.1. Soil sampling activities were performed during September and October 1993. One hundred thirty-nine (139) soil samples (including 11 duplicates) were collected and analyzed for a subset of the following analyses:

- TPH
- SVOC and VOC
- metals
- PCBs
- TOC
- physical characterization

Analytical results and spatial analysis for each set of parameters are presented below. Results of previous Site investigations (identified as Pre-RI data) are considered in the data interpretations; these data were tabulated in previous reports (GeoEngineers, 1991a and 1992a) and are presented in Appendix E. All laboratory analytical reports corresponding to RI soil samples are found in Appendix D.

5.3.1 Total Petroleum Hydrocarbons

TPH were analyzed in Site soils using at least one of three Washington analytical methods: 1) WTPH by 418.1, 2) WTPH-D as diesel, and 3) WTPH-G as gasoline. WTPH-418.1 by EPA Method 418.1 is an infrared (IR) spectroscopy method which quantifies all saturated compounds (i.e., alkanes). The method was designed primarily to estimate TPH concentration, and not to identify specific hydrocarbon mixtures. WTPH-D by EPA Method 8015 modified is a gas chromatography (FID) analysis which can be used to quantify diesel-range and beyond hydrocarbons (C_{10} to C_{28}). WTPH-G by EPA Method 8015 modified is a purge and trap method used to measure gasoline-range hydrocarbons (C_6 to C_{10}).

Field observations during the RI identified only small isolated areas of soil contamination with the exception of along the railroad tracks. TPH concentrations measured in Site soils during the RI are presented in Table 5-1. Surface soil samples were analyzed using WTPH-418.1 and concentrations ranged from non-detect to 4,900 mg/kg. Both vadose zone and aquifer soils were analyzed using a combination of the three analytical methods. TPH as gasoline were detected slightly above detection limit in only one of five samples analyzed using this method, indicating an absence of gasoline-range hydrocarbons in the subsurface soils. This result is consistent with products used at the Site historically.

In order to evaluate areal and vertical TPH distribution, several figures were prepared. Figure 5-5 presents the TPH concentration distribution in shallow soils (0–2 feet bgs) based on RI and previous data. Figure 5-6 presents the TPH distribution in vadose soils 2–6 feet bgs. Vadose zone refers to soils residing above the zone of water table fluctuation. Figure 5-7 presents TPH distribution across the Site in aquifer soils, or all soils residing within or below the water table fluctuation zone. The zone of contamination appears to extend to about 17 feet bgs, based on TPH results for confirmation samples (listed as "saturated-clean" in Table 5-1). If data were available for more than one aquifer sample per boring, the highest concentration is given in Figure 5-7. Cross sections showing TPH concentrations versus depth are shown in Figures 5-8 and 5-9, and correspond to the cross section locations given in Figure 5-2.

Figure 5-5 indicates that detectable TPH concentrations in shallow soils occur primarily within BNRR property. The majority of samples have TPH concentrations less than 1,000 mg/kg. The maximum shallow TPH value is 4,900 mg/kg at SS-28, located within the area of historic maintenance activities. The only TPH concentration detected in shallow soils north of the facility was an estimated value of 100 mg/kg at location HA-4. During septic tank excavations between Railroad Avenue and West River Drive, field observations indicate that residual LNAPL (or the

smear zone) is not encountered until depths of 3.5 feet or greater bgs. This observation agrees with the conceptual model for the Site which assumes that petroleum product occurs primarily in the zone of water table fluctuation (i.e., floats on groundwater).

TPH distribution at 2–6 feet bgs is limited to the eastern portion of the facility and downgradient areas. TPH concentrations range from non-detect to a maximum of 12,000 or 40,000 mg/kg (WTPH-D and WTPH-418.1, respectively) at sample location B-1 at a depth of 3.5 feet bgs. TPH values exceeding 1,000 mg/kg are observed at four locations outside of BNRR property. These locations occur within 300 feet of the river bank at wells MW-22, MW-23, MW-25 and MW-36. TPH concentrations given by the two analytical methods (WTPH-D and WTPH-418.1) vary by at least one order of magnitude in three of the samples (MW-22, MW-23 and MW-25), indicating either high carbon-range hydrocarbons or other organic matter. TPH measured in the MW-36 sample, however, is consistent based on the two methods. The 3,600 to 4,400 mg/kg TPH concentration occurs at 6 feet below ground surface. This sample depth is likely associated with the upper fringes of the water table zone.

TPH levels measured in aquifer samples are notably higher than TPH in the vadose zone, as shown in Figures 5-7, 5-8 and 5-9. The majority of soil samples with TPH exceeding 1,000 mg/kg, occur within and downgradient of the historic fueling and maintenance areas. Very low to non-detect TPH levels are found elsewhere within the Site. The maximum observed TPH concentration is 12,172 mg/kg (WTPH-D) or 27,000 mg/kg (WTPH-418.1) at DW-4 near the river bank.

There appears to be fairly good correlation between TPH values derived by the two methods, particularly with higher TPH concentration. In general, method WTPH-418.1 measured higher concentrations than WTPH-D.

5.3.2 Semivolatile Organic Compounds

Fifteen soil samples were analyzed for SVOC by EPA Method 8270 during the RI. The analytical results are presented in Tables 5-2A through 5-2C. SVOC, except for phthalates, were not detected in surface soil samples. SVOC detected in soil samples from the vadose and aquifer zones fall into two categories. The first is PAH compounds, and the second is phthalates. The phthalates, which were detected in relatively low concentrations (less than or equal to 300 Fg/kg), are attributed to laboratory contamination. PAH compounds are associated with the petroleum products and were found at concentrations of up to 8,300 Fg/kg (2-methylnaphthalene) and 7,500 Fg/kg (phenanthrene). These maximums were reported in the sample from boring B-4 at 10 feet bgs. Other PAH compounds detected in at least one boring, not including MW-39, were measured

at estimated concentrations less than the detection limit and include fluorene, fluoranthene, pyrene, and chrysene. The soil sample from borehole MW-39 at 6 feet bgs, contained ten different PAH compounds at estimated concentrations less than the detection limit. Additional PAH constituents detected only in MW-39 were benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene, and benzo(g,h,i)perylene.

2-methylnaphthalene was the most consistently detected PAH. The remaining PAH compounds detected are all considered priority pollutant PAH. Therefore, 2-methylnaphthalene and the sum of the priority pollutant PAH were selected for spatial presentation in Figure 5-10. Detected levels of PAH occur in the vicinity of the historical maintenance facilities.

5.3.3 Volatile Organic Compounds

Twenty-one samples were collected from the vadose zone and analyzed for VOC by EPA Method 8240. Analytical results are presented in Tables 5-3A and 5-3B. Methylene chloride, acetone, 2-butanone, styrene, 1,2-dichloroethane and 1,1,2,2-tetrachloroethane were the only VOC detected. Of these, methylene chloride and acetone were detected in the method blanks and are therefore considered to be the result of laboratory contamination. 2-butanone was detected only in sample B-9 at 7.5 feet bgs at 24 Fg/kg. 1,2-dichloroethane was detected only in sample MW-33 at 5 feet bgs at 9 Fg/kg. 1,1,2,2-tetrachloroethane was detected only in sample MW-37 at 7.5 feet bgs at 23 Fg/kg. Styrene was detected in five samples at concentrations ranging from 16 to 176 Fg/kg, as shown in Figure 5-11. These locations are primarily located within the former maintenance area. Low VOC levels in soils agree with the absence of WTPH-G as discussed above in Section 5.3.1.

5.3.4 Metals

Priority pollutant metals were analyzed in 53 vadose zone samples and in one sample at depth (10.5 feet bgs). Two background samples were included in the analysis. Analytical results are presented in Tables 5-4A and 5-4B.

Arsenic, chromium, copper, lead, nickel and zinc were the metals detected most frequently. Maximum concentrations of beryllium (1 mg/Kg), cadmium (16.6 mg/Kg), and mercury (59 mg/Kg) were reported in sample HA-2-1; this sample is off Site and the source of these metals is unknown. The highest cadmium and mercury concentration other than HA-2-1 were 3.7 and 0.3 mg/Kg, respectively. Beryllium, cadmium, selenium and thallium were generally not detected and when detected, were at concentrations near the detection limit. Silver and was not detected. Antimony concentrations ranged from non detect to 8.8 mg/Kg. Arsenic, chromium and nickel

concentrations ranged from non detect to 73 mg/Kg. Copper and zinc concentrations were within the range of 14 mg/kg to 460 mg/kg. Lead concentrations ranged from 3.6 to 3600 mg/Kg. Arsenic and lead were selected to further display metals distribution across the site and are further discussed below.

Arsenic distribution across the Site is presented in Figure 5-12, and is inclusive of data collected prior to the RI (pre-RI data). Approximately 14% of the samples analyzed contained arsenic at concentrations exceeding 20 mg/kg, including one of the background samples (BG-2) collected in a wooded area. Arsenic generally appears to be evenly distributed across the Site and may be indicative of naturally occurring levels. Two area were identified with slightly higher arsenic concentrations the former substation area and the current maintenance building. The statewide 90th percentile for arsenic is 7 mg/kg and the King County natural background arsenic concentration is reported as 7.3 mg/kg (Ecology, 1994b).

Lead distribution across the Site is presented in Figure 5-13 and includes pre-RI data. Elevated lead concentrations (i.e., exceeding 250 mg/kg) occur primarily within facility boundaries, with the exception of samples B-11 and HA-2. The higher lead concentrations appear to be located near the former substation area, in the former railyard, around the current maintenance building and around railroad tracks in the eastern portion of the facility. Sixty-seven percent of the measured lead concentrations are below 200 mg/kg and 89% are below 1,000 mg/kg. Relatively high lead (average concentration of 1,432 mg/kg), was measured in B-11 which is located in the school yard. The source of this lead is unknown.

5.3.5 Polychlorinated Biphenyls

Thirty-nine soil samples were analyzed for PCBs. The analytical results are presented in Table 5-5. Only one sample contained detectable PCB concentrations. PCB Aroclor 1254 was measured at a concentration of 1,200 Fg/kg in sample SS-27. PCBs were measured at estimated concentrations below the method detection limit in eight samples. Aroclor 1254 was detected in seven of these samples, and Aroclor 1260 in two.

Areal distribution of PCBs, including pre-RI data, is shown in Figure 5-14. PCBs are concentrated in three areas of the Site. Sample SS-27, with the maximum PCB concentration, is located just east of the former substation. Six other samples in the vicinity also contain detectable PCBs ranging from an estimated value of 14 Fg/kg to 330 Fg/kg. A small area to the east of the existing maintenance building, including samples SS-16, SS-19 and SS-21 contains total PCBs at

up to an estimated concentration of 175 Fg/kg. PCBs occur around the former roundhouse at estimated concentrations of up to 86 Fg/kg.

5.3.6 Physical Characteristics

Physical characterization including laboratory sieve analysis, falling head permeability testing, and moisture content determination was performed on selected samples. Samples were collected at various depths from three locations: B-10, DW-1 and MW-36. Results are presented in Table 5-6. Samples ranged from 69.6% silt and 17.2% clay (clayey silt) in MW-36 at 7.5 feet bgs, to 85.6% gravel and 11.9% sand (gravel with minor sand) in MW-36 at 6 feet bgs. These results concur with lithologies observed during drilling and summarized in Section 5.2. Laboratory-determined hydraulic conductivity ranged from 1.42×10^{-4} cm/sec (0.4 feet/day) to 2.79×10^{-2} cm/sec (80 feet/day). Hydraulic conductivity derived from falling head tests is usually representative of vertical hydraulic conductivity. Horizontal hydraulic conductivity is typically an order of magnitude greater than vertical conductivity due to compaction of sediments upon deposition. The range of measured hydraulic conductivity values are considered reasonable for the soils observed at the Site.

Natural moisture in the Site soils ranged between 3.2% to 20.1%.

5.3.7 General Chemistry

The general chemistry of Site soils was determined from the analysis of TOC. The data indicate that the TOC content of Site soils ranges from 0.2% to 2.7%. TOC concentrations are presented in Table 5-7.

5.4 Migration Routes in Soil

This section discusses the movement of petroleum product and other hazardous constituents through the unsaturated zone. This discussion focusses on constituents known to be present in Site soils.

5.4.1 Potential and Actual Migration Routes

Migration of contaminants in the unsaturated or vadose zone can occur via infiltration, percolation, evaporation and wind dispersal. Migration routes in the saturated zone are controlled

by the groundwater gradient, diffusion, mechanical dispersion, adsorption, retardation and microbial degradation. Migration via groundwater flow is discussed in Section 6. Migration to air via evaporation or particulate dispersal is discussed in Section 8.

The primary factors affecting vadose zone transport are the solubility, partitioning and degradation rate of the compounds of interest. When petroleum products are released to the ground surface, they will tend to travel downward through the unsaturated zone due to gravity. The extent to which the LNAPL will travel depends on the volume of the spill, its solubility in water, partitioning to soil (i.e., the tendency to sorb onto soil particles) and how quickly it is degraded or volatilized. LNAPL can exist in soil both as free-flowing and as residual contamination. For example, as LNAPL moves downward through the soil column, it tends to coat or adhere to soil particles, creating residual product. If sufficient LNAPL moves through the same area, the residual product, or that which is sorbed onto soil particles, will attain a maximum level. At this point, LNAPL will flow through soils previously coated in LNAPL to lower zones. In this manner, LNAPL can eventually reach the water table. Similarly, any soluble components of LNAPL are subject to downward movement with infiltrating and percolating water.

Based on the soil investigation results, it is apparent that LNAPL and specific contaminants have migrated downward through the vadose zone to the groundwater table. In particular, TPH levels measured in the zone of water table fluctuation are notably higher than TPH in the vadose zone. Metals and PCBs, on the other hand, tend to have higher concentrations in the vadose zone than at the water table interface.

5.4.2 Chemical Partitioning

Petroleum hydrocarbons are the predominant hazardous constituents present at the Site. Since TPH are comprised of many constituents, it is difficult to examine partitioning of LNAPL per se. However, individual constituents which may be attributed to petroleum hydrocarbons, or other substances used at the Site can be examined in this context.

Tables 3-2, 3-3 and 3-4 present solubility and soil partitioning coefficients for many of the constituents found at the Skykomish Site. Specifically these include PCB Aroclors 1254 and 1260, several volatile organic compounds (as listed in Table 3-3) and several PAH constituents. The PCBs found in Site soils are considered to be "highly chlorinated" isomers containing 54 and 60% chlorine, respectively. As such, they tend to adhere more strongly to soil and are less soluble, as indicated by the values presented in Table 3-4. The soils data presented in Section 5.3.5 support these conclusions as PCBs occur over a very limited area of the Site at very shallow depths.

PAH constituents detected in Skykomish soils include 2-methylnaphthalene, phenanthrene, fluorene, fluoranthene, pyrene, chrysene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, indeno(1,2,3-cd)pyrene and benzo(g,h,i)perylene. 2-methylnaphthalene is not identified as an EPA priority pollutant PAH compound; however, it differs from naphthalene only by an additional methyl group. Due to this structural similarity, the solubility and soil partitioning coefficients for naphthalene listed in Table 3-2 are expected to be applicable to 2-methylnaphthalene. It is therefore not surprising that 2-methylnaphthalene would be the most consistently detected PAH compound in Site soils. Other PAH compounds are detected less frequently, which can be attributed to low initial PAH concentrations in petroleum products used at the Site and also the low solubility and high K_{OW} values associated with these compounds. PAH compounds were detected at depths up to 12 feet bgs, indicating that these constituents have moved downward through the vadose zone soil. A contributing factor to this movement is relatively low fractions of organic carbon in the Site soil (Table 5-7).

Several VOC were detected in Site soil samples. The factors affecting fate and transport of these compounds are presented in Table 3-3. All of the VOC are fairly soluble and mobile. However, due to the low concentrations and limited extent of VOC at the Site, any migration of these compounds would be negligible.

6.0 GROUNDWATER INVESTIGATION RESULTS

Data concerning hydrogeologic conditions, groundwater quality, and free-phase NAPL occurrence were collected during the RI to further characterize the horizontal and vertical distribution of dissolved contaminants and free-phase product. RI information was also used to define factors controlling the fate and transport of contaminants.

6.1 Regional Hydrogeology

The Site is located within the Skykomish valley, a relatively steep-sided bedrock valley that has been partially filled with glaciofluvial sediments. The bedrock in the area consists of marine metasedimentary and metaigneous rocks overlain by volcanic and sedimentary rocks. As such, the bedrock has relatively low permeability. The glaciofluvial sediments filling the valley consist mainly of poorly- to moderately-sorted sand, gravel and cobbles. The base of the sediments appears to be located 200 to 250 feet bgs at the Site based on information obtained from logs of nearby water wells (GeoEngineers, 1993).

The direction of regional groundwater flow is westerly, in a downslope direction coincident with the slope of the floor of the valley. Locally, groundwater has a component of flow towards the Skykomish River.

6.2 Local Hydrogeologic Conditions

Local hydrogeologic conditions at the Site have been defined during the RI by observing borehole samples, physical testing of aquifer soils, conducting slug tests in several wells, and collecting water table elevation data. A total of 45 wells and 12 borings have been installed at the Site. Well locations are shown on Figure 4-1.

6.2.1 Aquifer Properties

The Site is situated on glaciofluvial sediments and is bordered on the north by the river. Across the river from the Site are bedrock cliffs. South of the Site, the valley of Maloney Creek is cut into the bedrock hillsides and extends southward from the central portion of the Site.

The aquifer at the Site is unconfined and extends from the water table (5 to 15 feet bgs) to the total depth of exploration (47 feet bgs). The upper 10 to 15 feet of the aquifer consist predominantly of gravelly sand to sandy gravel which locally contains a trace to some silt. Sandy silt and silty clay beds are present in the gravelly sand beginning at depths of 15 to 30 feet bgs. Beds are generally 3 to 5 feet thick but range up to more than 12 feet thick. These silty or clayey beds can commonly be traced between nearby wells, but are not extensive across the Site. Lithologic characteristics of the aquifer are discussed in more detail in Section 5.2.

Static water levels have been measured in Site monitoring wells periodically from October 1, 1990, to November 7, 1994. Gauging data is summarized on Table 6-1. All groundwater elevations are referenced to USGS benchmarks (National Geodetic Survey Datum [NGVD] 1929). Groundwater elevation data has either been collected through drop tubes, or has been corrected for the presence of product as indicated on Table 6-1.

Groundwater occurs at a shallow depth beneath the Site (generally 5 to 15 feet bgs). During the period of measurement, groundwater elevations across the Site have ranged from 917.49 to 931.81 feet msl. Elevations are highest at the southeast corner of the Site and decrease northwestward toward the river. Within a single well, the seasonal variation in groundwater elevation ranges from about 4 to 7 feet. Groundwater elevations are generally lower in the summer and early fall (June to early November) and higher during late fall, winter and spring (November to April). Maximum groundwater elevations have been measured in late November when rainfall is at a maximum.

Figure 6-1 shows hydrographs for wells MW-10, MW-19, MW-24 and MW-28 and includes rainfall data. The hydrographs demonstrate that variations in groundwater elevations in wells across the Site follow a similar pattern. Well 24, which is located adjacent to the river, follows a similar pattern to wells located further inland, suggesting that the river does not control groundwater elevations. In addition, changes in groundwater elevations correlate closely with monthly rainfall. Groundwater elevation response to rainfall is relatively rapid.

The hydraulic conductivity of aquifer materials at the Site were evaluated using laboratory and field tests. As discussed in Section 5.3.6, the grain size distribution and hydraulic conductivity of several borehole samples were analyzed in the laboratory. Two of these samples were from the aquifer. The sandy gravel to gravelly sand sample from a 12.5-foot bgs depth in borehole B-10 had a hydraulic conductivity of 79 ft/day (2.79×10^{-2} cm/sec) and a clayey silt sample from a 7-foot bgs depth in MW-36 had a hydraulic conductivity of 0.4 feet/day (1.42×10^{-4} cm/sec).

Hydraulic conductivities were estimated in the field using rising head slug tests. Slug tests were conducted in shallow wells MW-5, MW-36, and MW-40 and deep wells DW-1, DW-2, and DW-4. Well MW-40 did not contain sufficient water to fully cover the slug, so the data was not used for the hydraulic conductivity calculations. The recovery in each well was very rapid and, as a result, limited data points were recorded for each slug test. Several tests were conducted in each well and the best recovery data (i.e., most data points and best-fit line) from each well was analyzed using Geraghty & Miller's AQTESOLV program. AQTESOLV uses Bouwer and Rice's method (1976) for evaluating slug tests. The program constructs a recovery plot of groundwater elevation change versus time on a semi-log graph and a straight line is fitted to the plotted points. Pressure transducer data used to construct the recovery plots, input parameters, and recovery plots are included in Appendix F.

The hydraulic conductivities calculated from slug test results are summarized in Table 6-2. Recovery plots indicate that the best-fit data were collected from wells DW-1, DW-2 and MW-5. The calculated conductivities for these wells range from 41 to 84 feet/day and average 64 feet/day. Literature values for the corresponding aquifer material (sandy gravel to gravelly sand) support these results.

Slug test results from wells DW-4 and MW-36 are not considered representative of the Site. The plots for these wells were not the ideal straight-line plots for a slug test, and the literature values do not agree with the values calculated from these plots. The data from well DW-4 were very erratic and a line did not fit well through the data points for any of the runs. The calculated hydraulic conductivity of 9.4 feet/day is low for the aquifer material, a gravelly sand. One potential explanation for the erratic data is that the slug was not able to clear the transducer wire in this well and the transducer was disturbed each time the slug was removed. Additionally, this well was a flush-mount completion and it was difficult to secure the transducer cord. In the plot for well MW-36, a double straight-line effect was observed. Typically when this occurs, the first line is attributed to drainage of the gravel pack while the second line is more indicative of flow from the aquifer. Therefore, the second line is used to calculate the aquifer hydraulic conductivity. However, the calculated hydraulic conductivity (3.9 feet/day) is lower than expected based on literature values for a fine sand with a layer of gravelly sand (as described in the well log). This result may be a local heterogeneity of the aquifer or related to the interbedded nature of the aquifer.

6.2.2 Aquifer Flow Characteristics

Groundwater contour maps have been compiled using recent and historical gauging data. Groundwater contour maps constructed using previous data and miscellaneous gauging events

during the RI are included in Appendix G. Maps constructed during the quarterly RI monitoring events are included as Figures 6-2 through 6-5. In general, the groundwater flow is to northwest, down the valley and towards the Skykomish River. The flow direction is commonly northwesterly in the eastern and northwestern portions of the Site and west-northwesterly in the southwestern portion of the Site. During some gauging events, a ridge of locally higher groundwater extends from the former creek channel northwards toward wells MW-27 and/or MW-21. Locally, flow is northeastward on the northeastern side of the ridge; however, flow is diverted northwestward again before reaching the river. The ridge is very pronounced and linear during periods of high groundwater (i.e., April and November 1994) and more subdued or nonexistent during periods of lower groundwater elevations (i.e., November 1993 and August 1994). Differences in geology (zones of preferential flow) and recharge from the former creek channel are most likely responsible for the fluctuations in groundwater gradient and flow direction.

Minimum and maximum groundwater elevations during the RI were recorded on August 1, 1994, and November 7, 1994, respectively. During the August gauging event, the net horizontal groundwater gradient was 0.0083 foot/foot and the gradient was relatively consistent across the Site. During high water conditions in November, the net horizontal groundwater gradient for the Site as a whole was 0.0074 foot/foot. The gradient and flow direction varied from 0.0085 foot/foot north-northwestward in the eastern portion of the Site to 0.0174 foot/foot northwestward in the western portion of the Site.

Vertical gradients within the aquifer are relatively low and vary in direction from downward to upward. Vertical gradients were estimated using well pairs DW-2/MW-40 and DW-3/MW-30 and are summarized on Table 6-3. The well pair DW-2/MW-40 is located immediately adjacent to one another and provide high quality vertical gradient data. The gradient at DW-2/MW-40 ranged from 0 (no vertical gradient) to 0.074 foot/foot downward. The highest downward gradients occurred during periods of high groundwater levels (heavy rainfall), and the lowest gradient occurred when water levels were low (low rainfall). This variation in vertical gradient magnitude suggests that rainfall infiltration is a major factor recharging groundwater at the Site. Well pair DW-3/MW-30 is located approximately 100 feet apart; therefore, horizontal gradients between these wells will mask the vertical gradient measurements. Nevertheless, the vertical gradient data is considered worthwhile. At well pair DW-3/MW-30 gradients varied from 0.014 feet/foot downward to 0.029 feet/foot upward and averaged 0.017 feet/foot upward.

The groundwater velocity at the Site can be estimated using the hydraulic conductivities and gradients and the following relationship:

$$V = \frac{Ki}{n_e}$$

where: K = the hydraulic conductivity
I = the horizontal groundwater gradient
n_e = the effective porosity

The average groundwater gradient is 0.0079 feet/foot and the effective porosity is assumed to be 20% for a sand and gravel mix. The average hydraulic conductivity of the gravelly sand to sandy gravel which comprises much of the upper aquifer is 64 feet/day. Based on these values, the groundwater velocity is 2.5 feet/day. In siltier areas, groundwater velocities will be somewhat lower. The clayey silt bed sampled in MW-37 had a hydraulic conductivity of 0.4 feet/day and provides a low-velocity endpoint. The calculated groundwater velocity for the clayey silt is 0.015 feet/day.

The nature of groundwater interaction with the river and the water noted in the former creek channel was addressed during the RI. All data collected to date show Site groundwater recharging or in equilibrium with the river. None of the data collected to date have indicated that the river recharges the Site. The hydrographs support this conclusion; the well adjacent to the river has a similar hydrograph pattern and the magnitude of changes are similar to wells located further inland. A few inches of water have been noted in the former creek channel during wet months when groundwater elevations are high. Surface and groundwater elevations suggest groundwater is recharging the former channel during these periods. During drier periods, the former channel is dry.

6.3 Groundwater Quality Data

Groundwater quality was assessed in the RI through four quarters of groundwater sampling. Samples were collected from selected wells and submitted for analysis of TPH, SVOC, VOC, metals and PCBs. Analytical parameters and the wells sampled varied from quarter to quarter; wells sampled and the parameters analyzed for are summarized on Table 4-4. The selection of wells and analytical parameters was done in consultation with Ecology and considered numerous factors. When selecting the wells to be sampled, the location of each well relative to potential sources and receptors and to other wells was considered along with the past sampling results from that well or from nearby wells. The selection of analytical parameters for a given well considered the potential sources near that well and the past groundwater and soil samples from the well location and from adjacent areas. Following this process, the most wells were sampled for the most parameters in the initial RI sampling round. This first round was used to confirm pre-RI data and to establish an initial

understanding of groundwater quality at new well locations. Subsequent sampling rounds were more focused and involved fewer wells and fewer analytical parameters.

Prior to the RI, groundwater samples were collected from all existing wells without product during four sampling events between October 1990 and March 1992. Samples were analyzed for TPH, BTEX, SVOC, metals and PCBs. Groundwater from wells MW-1 through MW-27 were tested for TPH and BTEX four times and total metals once. Wells MW-28 through MW-32 were tested for TPH, BTEX, metals and PCBs during one sampling event. The previous data are presented in Appendix E and the analytical laboratory reports generated during the RI are included in Appendix H. The data collected during the RI generally supports previous data, with the exception of one PCB detection during previous work, which was not confirmed during the RI. As such, the following discussion focuses on the data generated during the RI.

6.3.1 Total Petroleum Hydrocarbons

During the first RI quarterly sampling event (November 1993), groundwater from 35 Site wells was analyzed for TPH using the Washington State analytical known as Method WTPH-D Extended. This analytical method uses the gas chromatography procedure described in EPA Method 8015 to quantify hydrocarbons in the C_{10} to C_{32} range (diesel and motor oil). During subsequent quarters, the number of wells sampled was reduced and the groundwater samples were analyzed using a modified version of Method WTPH-D Extended. This modified method is also based on use of EPA Method 8015 and quantifies hydrocarbons in the range of C_9 to C_{36}.

Hydrocarbon identification (HCID) analyses performed in January 1994 on various hydrocarbon samples obtained from the Site indicate a bell-shaped curve with a predominant hydrocarbon range from C_{10} to C_{28} with thin tails to C_{32} or C_{34}. Therefore, the modified WTPH-D Extended analysis (C_9 to C_{36}) fully encompasses the range of Site product hydrocarbons. The WTPH-D Extended method (C_{10} to C_{32}) used for groundwater Round 1 rather than the modified WTPH-D Extended also encompasses the vast majority of the hydrocarbons in the Site product. Therefore, use of WTPH-D in round 1 is considered to be valid and acceptable for the RI. Note that the initial laboratory reports (Appendix H) incorrectly refer to a hydrocarbon range of C_{10} to C_{28}; this reference was corrected in later lab reports.

TPH concentrations in groundwater for the four quarterly RI sampling events are presented in Table 6-4. The locations of the dissolved TPH groundwater plume and areas of free product for each quarter are shown on Figures 6-6 to 6-9. During the RI, Site-wide TPH concentrations ranged from less than 0.02 to 6.5 mg/L with one exception. A TPH concentration of 37 mg/L was measured

in well MW-11 during the November 1994 sampling event. A consistent seasonal variation in TPH concentrations is not apparent. However, concentrations in several wells vary with changes in the prevailing groundwater flow direction.

TPH concentrations correlate closely with areas where free product has been detected. TPH concentrations exceeded 1.0 mg/L only in wells where free product has been detected (as discussed in Section 6.4.1). The two exceptions to this trend are wells MW-13 and MW-14. TPH concentrations in groundwater from MW-13 ranged from less than 0.020 to 6.5 mg/L and in MW-14 concentrations ranged from less than 0.2 to 1.4 mg/L. These wells are located within 40 feet of one another and are downgradient of the former creek channel. Under some flow conditions, these wells are also downgradient of MW-39 which contains a viscous product. TPH concentrations in all other wells where free product has never been noted are less than 1 mg/L. TPH was not detected in the deep wells.

Historic TPH data (Table 6-4 and Appendix E) were evaluated to determine any trends in TPH concentrations. TPH concentrations have been measured periodically since 1990. Prior to the RI, samples were analyzed primarily by EPA method 418.1, while RI samples were analyzed by Washington methods WTPH-D and WTPH-D extended. Due to the different method the results can not be correlated directly. Yet the historic and RI data are generally consistent. The exception is the first pre-RI sampling period (October 1990). TPH was detected one to two orders of magnitude higher than any subsequent sampling events in five wells. As these anomalously high results have not been confirmed in any wells, they are attributed to a sampling or analytical problems and are not considered representative.

One historic sample was analyzed by a method similar to those used in the RI. In November 1991, the TPH concentration in well MW-28 was evaluated by EPA Method 418.1 and modified EPA Method 8015 for diesel and for gasoline. The average of two duplicate samples for these analyses were 150, 160 and 6.5 mg/L, respectively. The WTPH-D method used for analysis of the RI samples is based on use of the modified EPA Method 8015. Measured TPH concentrations in well MW-28 during the RI ranged from 1.5 to 6.4 mg/L. As discussed above, seasonal and long term trends in the TPH data are not evident. However, concentrations do appear to vary with the prevailing groundwater flow direction. This is believed to be the case for MW-28. Concentrations were high in November 1991 and in November 1994, product was detected in the well. Groundwater levels were high during both of these sampling periods. During intervening groundwater sampling events, groundwater concentrations were lower and product was not detected.

6.3.2 Semivolatile Organic Compounds

During the first three quarters of groundwater sampling, 24 wells were analyzed for SVOC or PAH compounds. SVOC analyses were not completed during the fourth quarter. During the first quarterly sampling event, groundwater samples were analyzed for SVOC using EPA Method 8270; during the second quarter, EPA Methods 8270 and 8310 were both used to determine PAH concentrations. Method 8310 was used during the third quarter. SVOC results are presented on Table 6-5 and the wells with detectable concentrations are highlighted on Figure 6-10.

Total PAH concentrations ranged from below detection to 18 µg/L with the exception of well MW-11 which had total PAH concentrations ranging from 53 to 234 µg/L. Carcinogenic PAH compounds were detected in wells MW-9, MW-11 and MW-28; concentrations ranged from 1 to 5 µg/L. The carcinogenic PAH compounds detected were chrysene and benzo(a)anthracene. With the exception of MW-37, free product has been detected in all wells containing detectable PAH compounds. Although free product has not been detected in well MW-37, this well is surrounded by wells where free product has been detected. Gravelly sands encountered during drilling of this well were reported to have an oily sheen.

Other SVOC detected include bis(2-ethylhexyl)phthalate, di-n-octyl phthalate and 2-methylnaphthalene. The phthalates were estimated at concentrations below the method detection limit and are attributed to laboratory contamination. 2-methylnaphthalene was detected at concentrations of 89 to 200 µg/L in well MW-11. Well MW-11 has had the highest PAH and TPH concentrations at the Site and has contained free-phase product.

SVOC were not detected in the deep wells.

6.3.3 Volatile Organic Compounds

Over the first two quarters, sixteen wells were sampled for VOC. During the first quarter, VOC were analyzed by EPA Method 8240; during the second quarter, EPA Method 8020 was used to analyze BTEX concentrations. Results of VOC analyses are summarized on Table 6-6 and wells with detectable concentrations are highlighted on Figure 6-10.

Methylene chloride and acetone were detected in several of the VOC samples and blanks. Chloroform was detected in one sample and a blank, and chloromethane was detected at concentrations below the method detection limit in one sample and a field blank. Methylene chloride, acetone and chloroform are commonly used in laboratory analysis. The presence of these

compounds in groundwater samples is attributed to cross-contamination in the laboratory or during handling and transport. Data quality and the presence of these compounds in blanks and samples are discussed in data validation reports for each quarterly sampling event (Appendix H).

With the exception of compounds attributed to cross-contamination, VOC were detected only in wells MW-11, MW-36 and MW-37. Product has been detected in wells MW-11 and MW-36. As discussed above, MW-37 is located within the free-product pool. In MW-11, 1,1-dichloroethene and benzene were detected at concentrations below the method detection limit. The maximum toluene, ethylbenzene and total xylene concentrations in MW-11 were 1, 5, and 22 µg/L, respectively. In well MW-36, toluene and total xylenes were detected at concentrations above the method detection limit (1 and 5 µg/L, respectively). Xylenes were the only VOC detected in well MW-37; the concentration was 5 mg/L.

6.3.4 Metals

Metal concentrations in groundwater were analyzed in 22 shallow wells and two deep wells during the four sampling quarters. Based on the results of the first quarter, the list of metals analyzed was reduced to arsenic, chromium and lead. During the first sampling quarter, samples were not filtered prior to analysis and therefore, the resultant concentration included both dissolved metals in groundwater and metals adsorbed to sediment particles. Both filtered and unfiltered samples were analyzed during the second quarter. For the third and fourth quarters, only the dissolved (filtered) concentrations were evaluated. During the second, third and fourth quarters, total suspended solids concentrations (TSS) were measured to show the relationship between sediment volume and metals concentrations. Results of the metals and TSS sampling are presented on Table 6-7.

During the first quarter, samples were analyzed for total PPMs. Silver, beryllium and thallium were not detected. Cadmium was detected in three wells at a maximum concentration of 0.0003 mg/L; antimony and selenium were detected in one well at maximum concentrations of 0.002 mg/L and mercury was detected in four wells with a maximum concentration of 0.0007 mg/L. Copper and zinc were each detected in eight wells at maximum concentrations of 0.32 and 0.52 mg/L, respectively. All these concentrations are below applicable drinking water standards. Nickel was detected in five wells; only the concentration in DW-2 exceeded the drinking water standard maximum contaminant level (MCL) of 0.1 mg/L. Groundwater samples from DW-2 had elevated TSS concentrations. During the first and second quarter, arsenic was detected in 18 wells and the concentration exceeded the MCL of 0.05 mg/L in four of the wells. Lead was detected in 16 wells in the first two rounds. The MCL for lead is under EPA review; an action level of 0.015 mg/L lead

has been established by EPA. Site groundwater samples exceeded this action level in eight wells. Chromium was detected in 11 wells in the first two rounds and concentrations exceeded the MCL of 0.05 mg/L in six of the wells. Based on these results, the list of metals for analysis were reduced to arsenic, chromium and lead.

During the second quarter, the validity of total metals concentrations was assessed. Two metal samples were collected from each well, one sample was filtered in the field and the other was not. The unfiltered sample was also analyzed for TSS to evaluate the correlation between TSS and metal concentrations. The results of sampling showed that samples with high TSS reported high metal concentration in the unfiltered samples. Unfiltered samples with low TSS concentrations and filtered samples contained metal concentrations near or below the detection limit. In addition, unfiltered metal results were erratic across the Site. Well MW-2, which is upgradient of most of the historic activities at the Site, contained some of the highest concentrations of arsenic and lead. Well MW-40 is near the former substation and contained high concentrations of metals, while adjacent wells MW-15 and MW-7 contained levels of arsenic and lead near or below the detection limit. Wells downgradient of the substation, MW-19 and MW-37, have had metals concentrations near or below the detection limit. Therefore, dissolved metals concentrations were found to be more representative of actual groundwater concentrations and only dissolved samples were collected during subsequent quarters.

During the three quarters of dissolved metals sampling, chromium was detected at low concentrations in one well and lead was detected at low concentrations in two wells. However, the chromium detection and one of the lead detections occurred on days when the respective metals were found in the laboratory blank. The lead detection not attributed to blank contamination was in well MW-36 and the concentration was 0.002 mg/kg. Arsenic was detected in seven wells, one of which was attributed to blank contamination. Maximum arsenic concentrations were reported in samples from wells MW-5, MW-9 and MW-36. Arsenic concentrations ranged from 0.006 to 0.011 mg/L in MW-9 and MW-36; where free-phase product has been detected. In MW-5, the maximum reported concentration was 0.009 mg/L. Residual product was noted during drilling of MW-5.

6.3.5 Polychlorinated Biphenyls

Groundwater from 13 wells was analyzed for PCBs during the quarterly sampling events. The wells analyzed were in the vicinity of PCB detections in soils or other areas of potential concern. Three of the wells were deep wells. PCBs were not detected in any wells. PCB data is presented on Table 6-8. Prior to the RI, PCBs were detected in well MW-32 at a concentration of

0.11 µg/L (Aroclor 1254). Groundwater samples from MW-32 were tested for PCBs during two quarters of the RI sampling and PCBs were not found at detection limits of 1.0 µg/L and 0.05 µg/L.

6.3.6 General Chemistry

The pH, conductivity and temperature of groundwater has been measured in the field during groundwater sampling events. In addition, the DO was measured in the field during the November 1993 sampling event. General chemistry data is summarized on Table 6-9. The pH varied from 5.57 to 7.56 and the conductivity varied from 19 to 550 µmhos/cm. Temperature varied from 5.1E to 16.3EC and averaged 8.7EC. This distribution of DO concentrations is shown on Figure 6-11. In general, DO concentrations were highest in wells distant from the TPH plume (2.5 to 5.5 mg/L) and low within the product and dissolved TPH plumes (1.3 to 3.0 mg/L). DO concentration in wells adjacent to the TPH plume were more variable. In deep wells, the DO ranged from 5.8 to 8.5 mg/L.

6.4 NAPL Occurrence

The distribution and character of the free-phase NAPL in the subsurface was investigated as part of the RI. Wells were evaluated for LNAPL and DNAPL, only LNAPL was observed. Information on the presence and thickness of free-phase product in wells was collected. Product samples were analyzed for physical and chemical analysis. In addition, product recovery tests were completed. After completion of the RI, four product recovery wells were installed as an interim action. The operation of the wells was initiated in January 1996 and the data obtained from the recovery wells will be used in the feasibility study to more fully evaluate product recoverability. The following discussion of LNAPL occurrence is based primarily upon the RI data but includes observations made during interim action recovery well installation.

6.4.1 LNAPL Distribution

LNAPL is present at the Site as residual contamination coating soil particles and as free-phase product floating on the saturated zone. Residual product is generally found in source areas and the zone of groundwater table fluctuation (smear zone) at and surrounding areas of free-phase product. Areas of residual product are defined by elevated TPH concentrations and an oily luster noted in boring logs. The distribution of residual product is discussed in more detail in Section 5.3.1. The following discussion focuses primarily on the distribution of free-phase LNAPL.

Table 6-10 identifies all of the Site groundwater monitoring wells and the well gauging events that were completed during the RI. Interim action recovery well data is not included because of the limited amount of data available at this time. Data on the measured thickness of product or other observed evidence of product in a well is provided for each gauging event. Product data is also included on the gauging table (Table 6-1). Table 6-1 indicates when groundwater levels have been higher than the screen such that free product may not be detected. The water level has extended above the screen during periods of high water in several wells. However, all shallow wells have been constructed such that product would have been detected during several gauging events if it were present. Areas where free-phase product has been detected on an intermittent and frequent basis and areas of residual product are shown on Figure 6-12. Figure 6-12 considers observations made during interim action recovery well installation and during local septic tank replacement projects undertaken
by area residents.

Product has been detected at least once in 20 of the 45 groundwater monitoring wells installed at the Site. Ten of the 20 wells that have been reported to contain product have had relatively consistent detections of product over time; these wells are: MW-6, MW-8, MW-15; MW-17; MW-20; MW-21; MW-22; MW-25; MW-27 and MW-39. Wells MW-11, MW-26, MW-28 and MW-36 have had sporadic detections of measurable LNAPL; these wells have been conservatively incorporated into the areas of LNAPL product occurrence on Figure 6-12. Another eight wells have never had a measurable LNAPL product thickness but have had one or two instances when droplets of LNAPL were reported to be present. These eight wells are: MW-7, MW-9, MW-12, MW-19, MW-23 and MW-24. These wells have been incorporated into the area of intermittent product occurrence. A sheen has been reported on wells MW-3 and MW-4; however, actual product has never been observed and these wells were not included in the area of free-phase product. Although product has not been detected in well MW-37 during the year of monitoring, it has been included within the area of intermittent product occurrence. Sediments from the water table had an oily luster and the well is surrounded by wells with intermittent or continuous product observations. Over a longer monitoring period, product may be detected in this well.

The distribution of free-phase and residual product suggest that three main pools of free-phase product are present at the Site. The largest product pool extends from the facility in a downgradient (west-northwest) direction towards the river. Product seepage along a portion of the river bank has been observed under low river stage (i.e., at SED-4 and SED-5 in the late fall). The river bank seepage occurs at a distance of about 650 feet downgradient of the facility. Two other smaller and discrete areas of product occurrence are located within the immediate area of the facility. The product pool in the vicinity of MW-39 is located in the southern portion of the facility

near a former oil pump house location. This area is thought to be very small in extent. Neither product nor a sheen have been noted immediately downgradient in the former creek channel during periods of high water. The third product area encompasses about 1 acre and is in the southeast portion of the facility surrounding wells MW-11 and MW-17 and the former engine house location. In addition, a small amount of product was detected in MW-28 during the fourth quarterly monitoring event. This data indicates that a small pool of free-phase product may also be present in this area.

As discussed in Section 4.2.4, accurate measurement of product thickness is difficult at the Site due to the viscous nature of the product. The data that has been collected indicate that product thicknesses typically have been less than 0.5 foot (Table 6-1). The maximum product thickness was measured in wells MW-17 and MW-20, at about 2.5 feet. Other wells with measured product thickness of greater than or equal to 0.5 foot are wells MW-8, MW-21, MW-22, MW-25 and MW-27. Product thickness within a well varies from one gauging event to another. The timing of maximum product thickness measurements does not correlate from well to well or with a particular time of year.

The observed variability in product occurrence and thickness is related to the various factors controlling product occurrence. The elevation of the water table and whether the water table was rising or falling at the time of measurement will affect product thicknesses. Migration of product in response to variations in groundwater flow directions affects both the occurrence and thickness of product over time. Subsurface heterogeneities appear to affect the continuity of the pool; product may be trapped above or below fine-grained lenses as the water table fluctuates and lateral product migration may be enhanced or inhibited by textural changes.

6.4.2 LNAPL Characteristics

Product characteristics were determined by laboratory analysis of four product samples collected at the Site. Samples were obtained from the river seep near SED-4/SED-5 and from wells MW-22, MW-27 and MW-39. Samples were analyzed for physical parameters including specific gravity, viscosity, surface tension and interfacial tension. Samples were also submitted for a TPH screening analysis. The analytical results are provided in Table 6-11 and Appendix I. Specific gravity and viscosity are both very temperature-dependent parameters. The samples were evaluated at 45EF to reflect the *in-situ* characteristics of the LNAPL; the temperatures measured in the aquifer range from 42E to 55EF. An increase in temperature would result in a decrease in specific gravity and viscosity. The other two parameters, surface tension and interfacial tension, are not as temperature-sensitive and were analyzed at room temperature.

The specific gravity of a liquid is defined as the ratio of the weight of a given volume of the liquid at a given temperature to the weight of the same volume of water at a given temperature. Most petroleum hydrocarbons have a specific gravity of less than 1. The specific gravity for the LNAPL samples at the Site range from 0.9676 (well MW-27) to 1.0054 (well MW-39). Three of the four samples were between 0.9676 and 0.9818. The value of 1.0054 implies that the sample is heavier than water. However, actual examination of a product sample shows that the product does not sink in water, but rather that it floats. Since it was not possible to filter the sample, it is probable that small particles of sediment were mixed with the sample and caused the erroneous reading. Another LNAPL sample was collected from well MW-39 for retesting and was reported to have a specific gravity of 0.9922.

The viscosity of a liquid is a measure of the forces that work against movement or flow when a shearing stress is applied. In other words, viscosity is a measure of the resistance of a liquid to flow. Viscosity is commonly measured in units of centipoise (cP). Water has a viscosity of 1 cP at 20EC (Lyman, 1982). Viscosity values from the LNAPL samples from the Site at 7.5EC (45EF) range from 1,035 cP (well MW-27) to 95,350 cP (well MW-39). Typical values of viscosity range from 3.3 cP in automotive diesel fuel up to about 22,000,000 cP for Bunker C fuel (No. 6 fuel oil) at 7.5EC (API, 1989). From the viscosity measurements obtained, the LNAPL product samples collected at the Site are probably a mix of diesel and Bunker C fuel. The LNAPL product in well MW-39 is comprised primarily of Bunker C fuel with little, if any, diesel.

Surface tension affects the extent of spreading of a liquid when spilled. It is also important with respect to the adsorption of the liquid onto solid surfaces. The surface tension causes the liquid to contract to a minimum area consistent with the mass of the material and the containing surface. The surface tension is defined as the force per unit length (dynes/cm) in the plane of the surface. The surface tension for most organic liquids is between 25 and 40 dynes/cm at room temperature. The surface tension of water is 72 dynes/cm at 25EC (Lyman, 1982). The values of surface tension for samples from Skykomish range from 33 dynes/cm (well MW-22) to 39 dynes/cm (the river seep).

The interfacial tension between an organic liquid and water affects such processes as the formation of stable emulsions, the resistance to flow through orifices, and the dispersion of droplets. When two immiscible or partially miscible liquids are brought into contact, the interface between them possesses free energy, the value of which is the interfacial tension. The value of the interfacial tension will be less than the greater of the two surface tensions of the two individual liquids. The units of interfacial tension are the same as for surface tension, namely, dynes/cm. Interfacial tensions of organic liquids with water range from zero for completely miscible liquids up to the

surface tension of water (72 dynes/cm at 25EC). Values of interfacial tension for the samples collected at the Site range from 25 dynes/cm (MW-39) to 81 dynes/cm (MW-27). The value of 81 dynes/cm appears to be an overestimate as it exceeds the surface tension of water at 72 dynes/cm.

The nature of the hydrocarbons in the samples was evaluated using Washington Method WTPH-HCID. This method uses a gas chromatograph and flame ionization detector to determine the carbon range of the hydrocarbons in the product. In samples with higher concentrations, the actual concentration can be estimated. In all four samples, hydrocarbons were found from C_9 to C_{32}. In product samples from the river and wells MW-22 and MW-27, hydrocarbon compounds were quantified in the diesel range (C_{12} to C_{28}) at concentrations of 430,000 to 490,000 mg/kg. The diesel range concentration in well MW-39 was 210,000 mg/kg. Hydrocarbons in the gasoline range ($>C_6$ to C_{12}) and the heavy oil range ($>C_{28}$) were not found at concentrations above the detection limits of 10,000 and 50,000 mg/kg, respectively.

Physical and chemical testing suggest that the product at MW-39 is markedly different than the product in the main pool. The specific gravity of the product at MW-39 is greater than the rest of the samples and the viscosity is an order of magnitude higher than the other values. In addition, the product from MW-39 contains approximately 21% hydrocarbons in the diesel range while samples from the main pool contain 43% to 49% hydrocarbons in the diesel range.

Product flow characteristics were evaluated by conducting product baildown tests in wells MW-17, MW-20 and MW-27. These wells were tested because the greatest measured LNAPL thicknesses have been reported in these wells. Due to the high viscosity of the product, accurate thickness measurements were difficult to collect. Product thickness was estimated using a bailer. The initial product thickness measurements ranged from approximately 0.01 to 0.04 foot in MW-20 to 0.2 foot in wells MW-17 and MW-27. Because of the difficulty in obtaining quick and accurate depth-to-water or product thickness measurements, the baildown test was modified so that only the depth to product was measured. Under the modified test procedures, the depth to product was measured and then a decontaminated stainless steel bailer was used to quickly remove the product. The depth to product was then monitored until the product returned to the pretest level or adequate recovery data had been obtained.

Due to the limited initial product thickness in MW-20, attempts to bail down the product were unsuccessful. No product was recovered from the well during bailing and no product recovery information was obtained from this well. In well MW-27, where the initial product thickness was 0.2 foot, the depth to product was lowered by 0.07 foot by bailing. One hour after bailing, the depth to product returned to within 0.03 foot of the original level, a recovery of almost 60%. Well MW-17

also initially had approximately 0.2 foot of product. Approximately 0.0625 gallon of product was removed from the well by bailing. In a 2-inch well, 0.2 foot of product equals 0.032 gallon. Therefore, approximately twice the initial measured volume was removed from the well during baildown. The product level returned to the pre-baildown level in less than 30 minutes.

In summary, two wells contained sufficient product to conduct useful baildown tests. The recovery rates of the product in each well varied. One well fully recovered shortly after baildown (MW-17), while the product recovery in the other well (MW-20) was much slower with about 60% recovery in an hour.

6.5 Migration Routes in Groundwater

This section reviews the fate and transport of fuel released to the subsurface and its constituents. Site-specific controls on migration are also discussed. Migration in the unsaturated zone was discussed in Section 5.4. This discussion will focus on migration in the saturated zone.

6.5.1 Potential Migration Routes

Hydrocarbons released to the subsurface migrate primarily downward through the unsaturated soils. Assuming that all the hydrocarbon released is not immobilized in the unsaturated zone as a residual phase, the product flows downward until it reaches the water table. Being less dense than water, the product accumulates on the water table and spreads under capillary forces. As more product accumulates, it begins flowing in the downgradient direction of the water table. Hydrocarbon constituents in the product pool then begin partitioning into the groundwater or soil vapor. In addition, the product pool moves up and down as the groundwater table fluctuates seasonally, coating the soils across this zone of water table fluctuation (the smear zone). As the water table fluctuates upward across the smear zone, more hydrocarbons are available for dissolution. Additionally, the water table responds to seasonal fluctuations more readily than the product and therefore, product becomes temporarily incorporated into the upper portions of the water table.

Once dissolved in the groundwater, hydrocarbons will migrate with the groundwater flow by advection, interacting with the rock or soil medium. Migration rates will depend on the hydraulic gradient and hydraulic conductivity of the soils and on the amount of contaminant retardation associated with adsorption and degradation. Hydrocarbon constituents will adsorb on soil particles, particularly external and intraparticle surfaces coated with soil organic matter. The adsorption of constituents will cause a net retardation in velocity of movement of the compounds relative to that

of groundwater. Organic contaminants can be degraded by biological or chemical processes, further decreasing the rate of contaminant transport.

Rates of free-phase product migration are also dependent on the hydraulic gradient and hydraulic conductivity of the soils as well as the density and viscosity of the product. Product will preferentially flow downgradient through more permeable lenses and beds in the aquifer.

6.5.2 Actual Migration Routes

The groundwater table at the Site is relatively shallow and much of the product released has reached and accumulated on the groundwater table. Hydrocarbon constituents have partitioned in the groundwater. Partitioning of hydrocarbons into the air phase at the Site is considered negligible due to the nature of the product. The dissolved constituents are migrating with groundwater; however, the rate of migration is slower than the 2.5 feet/day estimated for groundwater. The product migration is slowed by retardation and biodegradation. DO data from the Site indicate that biodegradation is occurring in the vicinity of hydrocarbon plumes because DO concentrations are much lower in these areas as compared to upgradient concentrations.

Dissolved constituents have migrated downgradient from source areas. The lateral boundaries of the dissolved hydrocarbon plume are in close proximity to the product pool. The upper portion of the aquifer is permeable and consists predominantly of sandy gravel to gravelly sand. Therefore, the groundwater plume has not been dispersed laterally by preferential flow through more permeable zones. The vertical gradient at the Site is somewhat variable, but averages being downward. Hydrocarbons have not been detected in deep wells, suggesting that vertical transport is minor.

Migration of product from source areas and dissolved plumes originating from areas of free-phase and residual product are dependent on the type of product and the prevailing hydraulic gradient. As such, the three main pools at the Site are discussed separately in the following paragraphs. Through the years, product released from the fueling area has migrated northwestward toward the river, forming the main product pool and acting as a source of hydrocarbons to groundwater. Migration of product and dissolved constituents has primarily been controlled by the prevailing groundwater gradient. Due to the homogeneous nature of the aquifer and consistent groundwater flow direction in this area, lateral spreading has been minimal. Despite the homogeneous nature of the aquifer, some variation in product occurrence is thought to be associated with siltier zones within the sandy gravel. For example, product is present upgradient and cross-gradient to wells MW-23 and MW-24; however, product has been detected in these wells only once.

The product pool at MW-39 has not experienced the migration similar to the pool associated with the fueling area. The viscosity of the product at MW-39 is one to two orders of magnitude higher than the main product pool and therefore, migration is limited by the high viscosity of the product. Fluctuations in groundwater flow direction in this area and local fluctuations in groundwater flow associated with the former creek channel influence transport of dissolved constituents in this area. During high water table conditions a north-south to northwest-southeast trending ridge is formed on the water table. The ridge is located either coincident with or immediately east of this area and therefore, flow direction can vary from west to northwest and on rare occasions, northeastward. Dissolved constituents thought to be associated with the product at MW-39 have been detected in MW-5, MW-12, MW-13 and MW-14, depending on the prevailing groundwater flow direction. The local flow conditions associated with the channel contribute to the changes in the magnitude of the dissolved plume. Measurements indicate that the former creek channel is recharged during periods of high water. During periods of high water, when flow from both sides of the creek are towards the channel, northward migration of dissolved constituents is limited. During dry periods, when groundwater is low, the former creek channel does not influence groundwater flow and dissolved constituents are detected at the higher concentrations in downgradient wells (i.e., MW-12).

The product pool at MW-17 has also not experienced the migration similar to the pool associated with the fueling area. The smaller overall volume of this pool has limited migration. Local variations in groundwater gradient have also limited the migration of product and groundwater in this area. The only well surrounding MW-17 to have product lies to the north (MW-11). In addition, well MW-34 (located north of the plume) contained detectable TPH concentrations during two of the four quarters while wells MW-10 and MW-18 (situated west northwest of the MW-17 pool) generally do not contain hydrocarbons. The pool at MW-17 lies on the east side of the groundwater ridge that has been noted extending northward from the former creek channel to wells MW-21 or MW-27. When this groundwater ridge is present, flow is locally diverted eastward and northward before turning back northwestward. During lower flow periods, the gradient is more directly to the northwest. The intermittent presence of this groundwater ridge and the variable flow directions associated with the ridge are thought to decrease the net transport of product and groundwater in this area.

6.5.3 Chemical Partitioning

Chemical partitioning of constituents from soils and product to groundwater and from groundwater back to soils is complex. Where uncontaminated groundwater migrates into areas of residual contamination or free product, hydrocarbons will partition from the product or soils into the

groundwater. Factors controlling the rate of partitioning into the groundwater from soils include the types of constituents adsorbed to the soils, the organic carbon content of the soils, the residence time of groundwater in contact with the soils, and the initial concentrations of the constituents in the groundwater. When the groundwater contacts the product, hydrocarbons will dissolve from the product into the groundwater. The solubility of the product will be substantially less than the solubility of any one constituent of the product, and the solubility will also depend on the initial hydrocarbon concentration of the groundwater. Finally, when the contaminated groundwater reaches soils which have not been previously impacted, hydrocarbons will partition out of the groundwater and onto the soils.

The actual composition of the hydrocarbons in the soils and product will vary somewhat across the Site. Heavier-end hydrocarbons will preferentially be adsorbed to soils, leaving the mobile product with a slightly different composition as compared to the original product. Biodegradation will also cause variations in the composition of adsorbed hydrocarbons and those in the dissolved plume.

Groundwater quality data indicate that few compounds have partitioned from the LNAPL into the groundwater. TPH concentrations are non-detect within short distances of LNAPL. No TPH or other organics were detected in deep groundwater samples.

7.0 SURFACE WATER AND SEDIMENT INVESTIGATION RESULTS

Surface water flow data was presented in Section 2 of this report. As described in Section 6, the Site groundwater recharges the two surface water bodies in the study area; the South Fork of the Skykomish River and Maloney Creek. This section presents the results of the RI sampling of surface water and sediments within these two water bodies and discusses the fate and transport of contaminants present in these streams.

7.1 Surface Water Quality Data

Surface water samples were collected from seven locations on four occasions during the RI. Figure 4-2 shows each of the surface water sampling locations. Sample locations SW-1, SW-2 and SW-3 are located along the current Maloney Creek channel. SW-1 is the upstream sample location, SW-2 is located near the confluence of current and former Maloney Creek channels, and SW-3 is located near the confluence of Maloney Creek and the South Fork of the Skykomish River. Sampling locations SW-4, SW-5 and SW-6 are along the river. Location SW-4 is the upstream sampling location, SW-5 is located near the previously observed oily seeps, and SW-6 is located just upstream of the confluence with Maloney Creek. Location SW-7 is in the former Maloney Creek channel.

In November 1993, surface water samples were collected from SW-1 through SW-6 for analysis of a full suite of compounds including SVOC, PPMs, TSS and TPH. No surface water sample was collected from location SW-7 in November 1993 because the former creek channel was dry at the time of the sampling event. No VOC analyses were planned because these compounds are rapidly volatilized from flowing surface water. No PCB analysis was planned because of the low water-solubility of these compounds and the distance from any potential PCB source area to surface water.

In subsequent sampling rounds, both the number of sampling locations and the analytical parameter list were reduced. Specifically, sampling locations furthest from the Site were eliminated from some sampling rounds and parameters with no previously detectable concentrations were eliminated. Sampling details and analytical results for each parameter are presented below. Laboratory analytical reports are contained in Appendix H.

7.1.1 Total Petroleum Hydrocarbons

During late summer and early fall when the river is low, seeps of oily groundwater have been noted along the banks of the Skykomish River; these seeps have been observed at the locations shown in Figure 6-12. Some petroleum sheen has been observed on the surface of the river water near these seeps.

Surface water samples were analyzed for TPH in each sampling quarter. The November 1993 samples were analyzed for TPH by WTPH-418.1 and the subsequent surface water samples were analyzed using the WTPH-D Extended method. Table 7-1 provides the TPH results for the surface water samples.

Sample locations SW-3, SW-5, and SW-6 were sampled in each of the four quarterly events. Location SW-7 was not sampled in November 1993 as discussed above, but was sampled in each of the remaining three events. Samples were collected from locations SW-1, SW-2 and SW-4 in the first sampling event only. The only locations with any reported detectable TPH in surface water were SW-5 and SW-6. Each of these sample locations had an estimated TPH concentration of 0.1 mg/L during the August 1994 sampling event. No other TPH concentrations were reported for surface water samples.

7.1.2 Semivolatile Organic Compounds

The six surface water samples collected in November 1993 (SW-1 through SW-6) were analyzed for SVOC by EPA Method 8270. In April and August 1994, samples were collected from SW-5 for analysis of PAH by EPA Method 8310. This location was selected for PAH analysis because of its proximity to the oily seeps previously observed along the river bank.

SVOC results are provided in Table 7-2. The only SVOC detected in the November 1993 surface water samples was bis(2-ethylhexyl)phthalate from location SW-6; the reported concentrations were 23 and 180 Fg/L in the sample and duplicate, respectively. Phthalates are considered a laboratory contaminant and the presence of this compound is not indicative of any surface water contamination from the Site.

The only PAH compound detected in surface water samples was fluoranthene. It was reported present at an estimated concentration of 0.4 Fg/L in SW-5 in the August 1994 sample.

7.1.3 Metals

Surface water samples were collected from six locations in November 1993 and were analyzed for 13 PPMs. In April 1994, samples were collected from SW-3, SW-5, SW-6 and SW-7 for analysis of both total and dissolved arsenic, chromium and lead. In August 1994, samples were collected from SW-3, SW-5 and SW-6 for analysis of total arsenic, chromium and lead. No metals analysis was conducted on the November 1994 surface water samples.

Table 7-3 presents the results of the metals analysis of surface water samples. No metals were detected during any of the sampling events. Arsenic was detected at 0.001 mg/L in the April 1994 field blank.

7.1.4 Field Measurements

Surface water temperature, pH, DO and conductivity were collected as part of the RI sampling and are present in Table 6-9. These data indicate that the water in both the South Fork of the Skykomish River and Maloney Creek is neutral to basic (6.6 to more than 10 su), has relatively low conductivity (22 to 338 µmhos/cm) and is well oxygenated (greater than 9 mg/L DO). The highest conductivity values were obtained during low stream flow conditions in August 1994. No significant differences were noted between the river readings and those from the creek. Surface water temperatures ranged from a low of 5.3EC in November 1993 to more than 15EC in August 1994.

7.2 Sediment Quality Data

Sediment samples were taken from seven sampling locations on October 7, 1993. Five of the sample locations were along the south bank of the river west of the Fifth Street Bridge. Two of the sample locations were in the former creek channel. Sediment samples were analyzed for TPH (WTPH Method 418.1), SVOC (Method 8270), VOC (Method 8240), metals (Method 6010/7060), and PCBs (Method 8080). One pre-RI sediment sample (SKY-1) was collected. Its approximate location was in the Skykomish River north of monitoring well MW-23. This sample was analyzed for TPH using EPA Methods 418.1 and 8015. Results are discussed below for each parameter. Figure 7-1 depicts the sediment sampling locations and presents the reported concentrations of select indicator parameters. Laboratory reports are presented with soil data in Appendix D. Pre-RI data is presented in Appendix E.

7.2.1 Total Petroleum Hydrocarbons

Table 7-4 presents the results of the TPH analysis of sediment samples. TPH was detected in sediment samples SED-4, SED-5, SED-6 and SED-7. The maximum TPH concentration (6,900 mg/kg) was reported in the SED-4 sample, which was collected from the oil saturated sands at the location of an oil seep. SED-5, also from the oil seep, had a reported TPH concentration of 990 mg/kg. Other samples from the river (SED-1, SED-2 and SED-3) contained no detectable TPH. The two samples from the former creek channel, samples SED-6 and SED-7, had estimated TPH concentrations below the detection limit of 97 and 99 mg/kg, respectively.

7.2.2 Semivolatile Organic Compounds

SVOC were not detected in any sediment samples (Table 7-5).

7.2.3 Volatile Organic Compounds

Table 7-6 presents the VOC results for the RI sediment samples. All of the sediment samples were reported to contain methylene chloride and five of the seven sample locations had reported concentrations of acetone. Methylene chloride and acetone are common laboratory solvents and were also detected in the laboratory method blanks. These compounds are therefore believed to be an artifact of laboratory contamination.

Styrene, the VOC compound detected most frequently in Site soils (see Section 5.3.3) was not detected in any of the sediment samples. The VOC compound 2-hexanone was detected in samples SED-4 and SED-5 at 320 and 20 Fg/kg, respectively.

7.2.4 Metals

The results of sediment metals analysis are provided in Table 7-7. Silver, beryllium, cadmium, and antimony were not detected in any of the sediment samples. Selenium, thallium and mercury were each detected in one or two sediment samples at concentrations equal or slightly above the analytical detection limit for those metals.

Copper, nickel, zinc, arsenic, chromium and lead were detected in all of the sediment samples. For most of these metals, the concentrations reported in the former Maloney Creek channel sediments were greater than those reported in the river sediments. For example, copper ranged from 10.9 to 15.7 mg/kg in the river and was reported at more than 34.6 and 36.4 mg/kg in the former

creek channel sediments. This difference in creek sediments may reflect difference in organic and/or mineral composition. The river sediment data were examined to determine if metals were elevated near the observed oil seeps at SED-4 and SED-5. The maximum reported concentrations of metals were not in either the SED-4 or SED-5 samples near the oil seeps.

7.2.5 Polychlorinated Biphenyls

None of the sediment samples contained detectable concentrations of PCBs (Table 7-8).

7.2.6 Total Organic Carbon

Sediment samples were analyzed for TOC concentrations. The data indicate that the TOC content of the river sediments ranges from 0.3% to 0.8%. This relatively low TOC is in agreement with the observed sandy, gravely nature of the river bottom and with the seasonally high stream flows that occur in the river. The sediments of the former creek channel contain a significantly higher TOC with reported concentrations of 2.1% and 3.1%. The former creek channel sediments contain a higher TOC due to contributions from decaying organic matter such as leaves and other vegetation. The low stream flows in the creek do not scour or otherwise remove these organic deposits, allowing them to accumulate. The TOC sediment data were reported with the soil TOC values in Table 5-7.

7.3 Migration Routes in Surface Water and Sediments

7.3.1 Actual and Potential Migration Routes

Surface water and sediments receive runoff and groundwater recharge from the Site. Contaminants may be discharged to Maloney Creek from Site runoff that drains or groundwater that discharges to the former creek channel. These same mechanisms can also result in the release of contaminants to the river. Site runoff can enter the river via storm drains and groundwater discharges to the river. The release of petroleum product from seeps located along the south bank of the river has been observed on a seasonal basis. This seepage results in the formation of petroleum sheens and a release of contaminants to surface water and sediments. Based on the RI results discussed above, there is evidence that groundwater discharges of oily water have a measurable impact to river sediments.

Petroleum sheens on the water surface and contaminants dissolved in the surface water are subject to downstream transport, biological degradation, photo-oxidation and adsorption onto sediments. Contaminants present in sediments may be degraded, desorb into surface water or be transported downstream as suspended sediments. Given the overall high quality of the surface water and sampling results, there appears to be minimal occurrence of additional contaminant migration via surface water.

7.3.2 Chemical Partitioning

Both surface water and sediment samples were collected from similar locations in the river (SW-5 and SED-4) and in the former creek channel (SW-7 and SED-7). Review of these data were conducted to evaluate the site-specific partitioning between sediments and surface water. The only compound detected in both surface water and sediments was TPH. The SED-4 sample from the river was reported to contain 6,900 mg/kg while the nearby surface water contained at maximum of 0.1 mg/L. These data indicate a ratio of 10,000 to 1 for sediment and surface water partitioning. This relatively high partition coefficient may be due, in part, to the fact that the flow water does not have ample time to reach equilibrium with the underlying sediments. Even stronger partitioning onto sediments would be expected in the former creek channel because these sediments have a higher TOC concentration than the river sediments. However, the slower water flow in Maloney Creek may provide more time for dissolution and desorption which could counter the impact of the high TOC.

8.0 AIR QUALITY INVESTIGATION

8.1 Air Shed

The term air shed denotes a geographic area which, because of topography, meteorology and climate, shares the same air. The air shed associated with the Site is defined by the boundaries of the Skykomish Valley. The elevation at the Site is less than 1,000 feet above msl; elevations in excess of 2,000 feet above msl lie within 1 mile north or south of the Site. The valley trends east-west and defines the predominant wind direction at the Site. Local meteorological data are limited in terms of actual wind-speed and direction statistics (see Section 2.4).

The local air quality complies with ambient air quality standards such that the area is designated as an attainment area. The Skykomish area is not a designated Class I area pursuant to §§ 162 or 164 of the Federal Clean Air Act.

8.2 Air Monitoring

Air monitoring was performed at the Site during field activities to ensure worker safety and to gather information on volatile organic emissions. A PID was used for both health and safety monitoring and to obtain total organic vapor measurements. This instrument is designed to measure organic vapor levels in the range of 0 to 2,000 parts per million (ppm) on a volume basis. As a contingency, benzene monitoring, using Drager tubes, was to be performed during the RI if PID readings exceeded 1 ppm over a 5-minute period.

The following field activities included air quality monitoring using the PID:

- hollow-stem auger drilling
- well installation
- surface soil sampling
- sediment sampling
- hand auger sampling
- air rotary drilling

For these activities, readings were obtained at ground level and in the breathing zone (5 to 6 feet off the ground). During air rotary drilling, readings were additionally obtained from the cyclone exhaust and at the top of the well casing while drilling the borehole. For surface soil and sediment

sampling, the instrument was passed several times over the excavated area to obtain a reading. Additional air monitoring was performed in conjunction with well gauging events. PID readings were obtained at the wellhead immediately upon opening the well cover. The PID was calibrated daily, prior to use. Measurements were conducted in accordance with RETEC Standard Operating Procedure #320 presented in the SAP (RETEC, 1993).

Air monitoring results obtained during drilling and soil sampling activities are presented in Table 8-1. Total volatile organics concentrations in the breathing zone were consistently non-detect, with the exception of one reading of 0.5 ppm during sediment sampling. As a result, benzene air monitoring was never required. Volatile organics were only detected at appreciable levels during hollow-stem auger drilling of boring B-10, and from the top of the casing during air rotary drilling of boring B-7.

Instantaneous PID readings taken upon opening well covers are listed in Table 8-2. These values ranged from below background to 28 ppm. In most cases, detected values correspond to wells with measurable LNAPL accumulations.

8.3 Soil to Air Model

Under typical conditions at a site, the surface soil can release compounds of interest into the air via volatilization and through fugitive dust emissions. This section describes the procedures used to estimate emissions from volatilization and fugitive dust. These estimated emissions were then combined in a box dispersion model to yield estimated Site air concentrations.

The methodology used is suited to estimating long-term (i.e., chronic) air concentrations immediately above the areal soil source due to long-term emissions from surface soils. The methodology can also be used to estimate air concentration at the perimeter of the areal source due to emissions from surface soils.

8.3.1 Volatile Emission Estimates

The average rate of volatile emission from soils depends on the properties of the chemical, the depth of contamination, and the time over which the emission rate is averaged. The analysis conducted for the Site is based on a model developed by Clark Allen of Research Triangle Institute (the RTI model as presented in EPA, 1989a). This model assumes that volatile emissions from the surface of the soil mixture are limited by the diffusion of vapors through the pore spaces in the soil

mixture. The model further assumes an equilibrium concentration of organic vapors exists at all times within the soil pore spaces. Appendix J provides further detail on the model assumptions and equations used.

8.3.2 Fugitive Dust Emission Estimates

The average rate of fugitive dust emissions from the soil is determined by estimating the rate at which dust is blown into the air. Soil characteristics including grain size and moisture content impact the rate of dust generation. The rate of dust emissions for the Site was estimated using the fugitive dust emissions model of Cowherd (1984) (as described in GRI, 1988). Appendix J contains the details on the model input and assumptions.

8.3.3 Box Dispersion Model

The nearfield box dispersion model of Pasquill (1975) was used to estimate concentrations of compounds of interest in the air from surface emissions of volatiles and particulates. The model assumes a box exists above the areal source and it mixes the emissions within this box to generate an air concentration (Appendix J).

8.3.4 Calculated Air Concentrations

The above analyses were conducted using surface soil quality data from the railyard (South Site) and using surface soils quality data collected from non-railyard locations (North Site). Further discussion of the basis for separating the Site into these two areas is provided in Section 11. Table 8-3 presents the soil concentrations for each of the PPMs, the two detected PCB congeners and the SVOC and VOC detected most frequently in soils. The calculated air concentrations for each compound is then presented for volatiles, fugitive dust and total emissions. These results indicate that the air quality impacts from the Site are negligible. Only four compounds have estimated air concentrations that total more than 0.00001 mg/kg. These four compounds are: mercury, 2-methylnaphthalene, butyl benzyl phthalate and xylenes.

8.4 Migration Routes

8.4.1 Actual and Potential Migration Pathways

Section 8.3 and Appendix J describe how compounds can migrate from soils to air as vapors or as particulates. Contaminant migration in air is controlled by wind direction and speed, cloud cover, air temperature, and other factors including the formation of inversions and the presence of fog.

Based on the health and safety air monitoring conducted during the RI and on the analysis discussed in Section 8.3, there do not appear to be any significant actual migration pathways. Future excavation of contaminated soils could result in a potential increase in emissions and in the migration of contaminants via this pathway.

8.4.2 Chemical Partitioning

A detailed discussion of the factors that influence or control chemical partitioning from soil to air is provided in Appendix J.

9.0 INTERIM REMEDIAL ACTION

This section describes the LNAPL recovery system that was installed at the BNRR facility. The interim remedial action objectives were to provide data to assess the effectiveness of product recovery for the FS and reduce the release of oily seeps to the Skykomish River.

Ecology approval of the Interim Actions Plan was received in October, 1995. Construction of the interim action was initiated in October. Installation was completed and system startup was initiated in January 1996.

As discussed in previous sections, an LNAPL mixture of diesel and Bunker C fuels is present beneath the facility and adjacent properties, and oily seeps have been noted on a seasonal basis along a portion of the bank of the river. Recovery wells installed along West River Drive will facilitate recovery of petroleum product and reduce the amount of product reaching the river (Figure 9-1). The recovery wells were installed in areas believed to have floating product based on the RI. Hydrocarbon belt skimmers were installed in each recovery well to recover LNAPL. An additional monitoring well was installed to facilitate monitoring system performance. The new and existing monitoring wells will be used to detect the presence of product and gauge water levels to help monitor system performance.

9.1 Basis of Design

The following factors were considered in design of the LNAPL recovery system:

- The wells must be designed in a flexible manner to allow potential future use as dual pump recovery wells.
- The recovery wells must be screened to intercept the zone of water table fluctuation and to allow potential pumping of groundwater.
- The equipment and materials for the system must be compatible with diesel and Bunker C hydrocarbons.
- The hydrocarbon recovery system must be effective for highly viscous product.
- The system will accommodate a possible decrease in product recovery during the winter due to increased product viscosity.

- The native soils range from sand to gravel.
- The implementation plan should be staged in order to determine recovery rates and remote storage needs.

9.2 Rationale for Recovery and Monitoring Well Locations

Recovery Wells

Figure 9-1 illustrates the area of product occurrence at the Site and the recovery well locations. As presented in Section 6.4, monitoring well data indicate a continuous area of LNAPL flowing west-northwest towards the South Fork of the Skykomish River. LNAPL seepage along portions of the river bank has been observed under low river stage during the fall. LNAPL is also encountered in wells MW-23 and MW-24 sporadically, and in MW-25 consistently. Based on these observations, the recovery wells were located as indicated on Figure 9-1. The wells were placed in areas known to contain LNAPL; wells are not located in areas where product has not been consistently observed (e.g., MW-23 and MW-24).

Monitoring Well

As shown in Figure 9-1, recovery well R-4 was located within 20 feet of monitoring well MW-25. In order to evaluate system performance in the western portion of the recovery system, an additional monitoring well (MW-41) was installed adjacent to existing DW-4 and R-2. This well was screened across the water table to detect LNAPL, if present, as well as provide information regarding vertical gradients in combination with DW-4.

9.3 Well Design

The recovery and monitoring wells were constructed in accordance with WAC 173-160, Minimum Standards for Construction and Maintenance of Wells.

Recovery Wells

The recovery wells were designed to recover LNAPL using a belt skimmer. Therefore, the recovery wells were constructed to intercept the water table at all times based on gauging data for the area. The wells were constructed using stainless steel casing and screen. The wirewrap well screens were each 15 feet in length with 0.020-slot size. A 10/20 filter pack was placed in the

annulus around the screens. A 2-foot sump was installed below each screen to act as a sediment trap. The wells were enclosed in 3 foot by 4 foot vaults. The well logs are provided in Appendix C.

Monitoring Well

Monitoring well MW-41was also designed to screen across the water table at all times. This well will assist in evaluating recovery system performance (specifically near well R-2) and will also be used with existing monitoring well DW-4 to assess vertical gradients. The monitoring well was constructed of 4 inch diameter Schedule 40 PVC screen and casing. The well screen was 15-feet in length with 0.020-inch slots and extended from 4 to 19 feet bgs. A standard, flush-mounted well monument was place around the well. The well log is provided in Appendix C.

9.4 Findings

During drilling, hydrocarbon-saturated soils were observed at the water table in the recovery wells and the monitoring well. The observation of hydrocarbon-saturated soils in well boring R-1 required additional borings. As per the Interim Action Plan, two additional step out boring were installed to evaluate the horizontal extent of contamination to the west. The borings (SO-1 and SO-2) were drilled at approximately 50-foot spacings to the west of R-1 (Figure 9-1) to define the western LNAPL plume boundary. The borings were drilled to the water table and a soil sample was collected from the water table zone and submitted for a modified WTPH-D extended analysis (C_9 to C_{36}). The borings were then backfilled with bentonite to the surface. Boring logs are provided in Appendix C.

No evidence of contamination was observed above the water table. The analytical result of the 2 samples were:

- SO-1 - collected at 5 feet bgs contained 1,400 mg/Kg TPH as diesel and 1,300 mg/Kg TPH as motor oil.
- SO-2 - collected at 6.5 feet bgs contained 590 mg/Kg as diesel and 68 mg/Kg as motor oil.

The laboratory analytical report for these samples are presented in Appendix K.

To install the vaults around the recovery well, 3 foot deep excavation were required. The soils in these excavation were visually evaluated for evidence of contamination. No contaminated soils were observed in these excavations.

At the same time the interim action installation was occurring, local residents were replacing a septic tank. The houses are located along west side of Fifth Street south of West River Drive. During excavation, groundwater was encountered at approximately 5 feet 7 inches bgs. Once the sediment had settled the groundwater was clear and only a limited number of very small (1 to 2 inches in diameter) petroleum sheens were observed in the excavation. No LNAPL was present at this location.

10.0 REGULATORY CLASSIFICATION AND STANDARDS

No waste generation is currently associated with operations at the facility. Investigation-derived wastes (e.g., soil cuttings and purge water) are currently stored in drums at the Site; these wastes have been sampled and determined to be non-hazardous under RCRA and Washington Dangerous Waste regulations.

Additional wastes may be generated as part of Site cleanup measures. Such wastes could include contaminated soils, recovered LNAPL and contaminated groundwater. Based on the RI, neither soils nor groundwater would be considered hazardous waste under RCRA or Dangerous Waste regulations. Recovered LNAPL destined for disposal could be considered a dangerous waste due to persistence or aquatic toxicity. Recycle and reuse opportunities exist for recovered LNAPL, however, such that disposal of this material is not anticipated.

11.0 RISK ASSESSMENT

11.1 Scope of the Risk Assessment

This section of the RI report evaluates potential human health and ecological effects associated with exposure to chemicals of interest detected in soil, groundwater, surface water, and sediment at the Site. The elements of the risk assessment include:

- identification of chemicals of interest (Section 11.2)
- assessment of human health exposure (Section 11.3)
- assessment of ecological exposure (Section 11.4)
- summary of human health and ecological risk assessments

This format complies with the MTCA Cleanup Regulation (Chapter 173-340 WAC), MTCA Cleanup Levels and Risk Calculations (CLARC II) Update (Ecology, 1994), and current EPA guidance for conducting a human health evaluation, *Risk Assessment Guidance for Superfund* (EPA, 1989b and 1991).

11.2 Identification of Chemicals of Interest

The previous section of this report presented analytical results for numerous chemical compounds that were analysis in soil, groundwater, surface water and/or sediment samples. The purpose of this section is to review all these applicable data and ensure that the analysis of potential risks is focused on the appropriate chemicals. WAC 173-340-708 (2) allows for the selection of indicator hazardous substances when defining site cleanup levels. Because this is a similar application, the WAC requirements are reviewed below. WAC 173-340-708 (2)(b) lists the following factors that need to be considered when eliminating hazardous substances from further evaluation:

- the toxicological characteristics of the chemical relative to its concentration at the site
- the persistence and mobility of that chemical in the environment
- natural background levels of the chemical
- the thoroughness of testing for that chemical
- the frequency at which the chemical has been detected
- the degradation by-products of the chemical

This section reviews each of the above factors in two phases. First, the natural background levels, the thoroughness of testing and the frequency of detection are examined to identify the chemicals that are likely to be Site-related and to determine whether or not the analytical data are of acceptable for use in the risk assessment. The result of this initial evaluation is a list of chemicals of interest (COI) that will be used in a quantitative risk assessment. The second phase, the qualitative risk assessment, examines the toxicity of that chemical relative to its concentration at the site, discusses the persistence and mobility of that chemical in the environment and reviews available data regarding potential degradation by-products.

This procedure also complies with current EPA guidance (EPA, 1989b) which specifies completion of the following detailed steps:

- Segregate the analytical data into data sets by medium. The data are evaluated separately for each medium since different analytical procedures were used for each medium (e.g., soil, sediment, groundwater, and surface water).
- Evaluate the analytical methods for each data set for their suitability for risk assessment.
- Evaluate the detection limits for each analytical method and each data set.
- Evaluate qualified or coded data to determine data useability in the risk assessment.
- Compare sample results to results of field and laboratory blanks to determine whether or not detected chemicals are due to Site conditions or result from activities that occurred during sampling and analysis.
- Compare sample results to results of available background samples to determine whether or not detected chemicals result from activities at the Site or are related to ambient (background) conditions.

EPA guidance (EPA, 1989b) then recommends a final screening at the conclusion of the data evaluation procedure. The purpose of this final screening is to eliminate chemicals that are common laboratory contaminants, are detected at very low concentrations, and/or are detected in only one or a few samples (i.e., low detection frequency). These chemicals are not considered relevant for estimating potential risks. The outcome of this procedure is a list of COI for soil, sediment, groundwater, and surface water for use in the quantitative risk assessment. Figure 11-1 presents a schematic of the data evaluation process.

Numerous soil, groundwater, surface water, and sediment samples were collected during the RI and previous Site investigations. These samples were obtained over a large area, including the former maintenance and fueling facility as well as adjacent properties. Based on these factors, the Site was divided into two study areas to facilitate the assessment. The North Site includes soil and sediment samples collected north of Railroad Avenue. The South Site includes soil and sediment samples collected on or south of Railroad Avenue which are likely to be associated with the facility activities. Because the groundwater associated with the Site originates from the same aquifer, all groundwater data was summarized together in the risk assessment. The surface water samples collected from the South Fork of the Skykomish River, Maloney Creek, and the former channel of Maloney Creek were also summarized together for the risk assessment.

11.2.1 Soil Data

Review of soil quality data for risk assessment purposes is typically limited to soil samples collected from above the depth of groundwater. This is because those soils present the greatest potential for human exposure to chemicals from direct contact or inhalation. Soils that are present within the groundwater zone can also contribute to risks by the leaching of chemicals from soil to groundwater followed by contact or ingestion of groundwater. Because Skykomish is not the site of a recent spill (i.e., sufficient time has passed to allow chemicals that might leach to groundwater to do so), actual groundwater quality data will be used to assess the potential risk associated with chemicals leaching from soil. As was presented in Section 6, the depth to groundwater at the Site is relatively shallow (e.g, 5 to 15 ft bgs). In addition, MTCA requires that soil cleanup levels based on human exposure via direct contact be applied to the soil within the upper 15 feet (WAC 173-340-740(6)(c)). For these reasons, all soil data collected from 0 to 15 feet bgs were included for evaluation in this risk assessment. Table 11-1 is a summary of the soil and the associated parameters analyzed.

Following the detailed EPA guidance, the first step in the data evaluation process is the evaluation of analytical methods implemented on soil samples collected at the Site. The analytical methods listed in Table 11-1 are all EPA- or Ecology-approved methods. Tables 11-2 and 11-3 provide a summary table of the analytical data for soil samples collected from 0 to 15 feet bgs at the North Site and South Site areas, respectively. The summary includes the number of samples, the number of positive hits per chemical in the samples, the number of samples below detection limit (BDL), the minimum and maximum detection limits, the minimum and maximum concentrations in the sample, and the location of the maximum concentration. Metals, TPH, and VOC were detected in the North Site samples. Detected in the South Site samples were metals, PCBs (Aroclor 1254 and 1260 only), SVOC, TPH, and VOC.

The second data evaluation step involves evaluation of sample analytical detection limits. Sample analytical detection limits refer to the specific detection limits reported by the laboratory for a specific chemical and sample. The analytical detection limits for the soil samples ranged from:

North Site

- 0.02 to 2.4 ppm or mg/kg for metals
- 346 to 13,953 parts per billion (ppb) or µg/kg for SVOC
- 101 to 119 ppm for TPH (418.1)
- 5 to 26 ppm for TPH as diesel
- 5 to 52 ppb for VOC

South Site

- 0.02 to 10 ppm for metals
- 80 to 200 ppb for PCBs
- 330 to 33,000 ppb for SVOC
- 5 to 133 ppm for TPH (418.1)
- 5 to 30 ppm for TPH as diesel
- 5 to 6 ppm for TPH as gasoline
- 5 to 500 ppb for VOC

Detection limits for the North Site SVOC were high in two of the four samples (i.e., HA3-1 and HA4-0). However, TPH detection limits were acceptable and no TPH were detected in the two samples with high SVOC detection limits. Therefore, the SVOC normally associated with diesel and/or bunker C fuel are not expected in these two samples as indicated by no TPH detection. The detection limits for all other soil samples are considered acceptable for the risk assessment.

The third evaluation step includes review of qualified or coded data. The soil samples were qualified with standard EPA qualifiers of B and J in the reports obtained from the laboratory. A qualifier of B indicates a parameter was also detected in the lab blank; a J qualifier indicates an estimated value less than the sample detection limit. J values were considered valid results for analysis of COI (EPA, 1989b). Concentrations that were below the detection limit were signified with a U qualifier.

The fourth evaluation step in the data validation process involved comparing the field sample data with field and laboratory blanks. Comparison of concentrations detected in the blanks with concentrations detected in the samples is common procedure and ensures that only Site-related data

are used in the risk assessment. Methylene chloride and acetone, common laboratory contaminants, were found in the laboratory blanks associated with almost all the soil samples analyzed for VOC.

MTCA defines natural background as "the concentration of hazardous substance consistently present in the environment which as not been influenced by localized human activities: (WAC 173-340-200). The Site is located in a geologic region in which there are several naturally occurring chemicals in the soil and groundwater. EPA guidance (EPA ,1989b) suggests the elimination of COI if the maximum concentration detected in a particular medium is less than or equal to the background concentration in that medium. Two background surface soil samples (BG1-0 and BG2-0) were collected and analyzed as summarized in Table 11-4. Table 11-4 includes data compiled by Ecology on natural background concentrations of metals in soil throughout Washington State (Ecology, 1994b). A comparison of these background concentrations to the maximum detected concentrations in North and South Site soils is presented in Table 11-5. Thallium in the South Site is the only chemical eliminated as a COI because its maximum detected concentration is less than (or equal to) the natural background concentration.

The *Risk Assessment Guidance for Superfund* document (EPA, 1989b) allows further reduction of the list of chemicals of interest following the initial data evaluation process. EPA guidance (EPA, 1989b) suggests eliminating chemicals if:

- the chemical is a common laboratory contaminant
- the chemical has a low detection frequency
- the chemical is detected at low concentrations

MTCA also specifies the detection frequency as a factor in selecting indicator hazardous substances (WAC 173-340-708(2)(b)(vi)). Under MTCA, low concentration is also a factor if it considered in light of the toxicity of the compound (WAC 174-340-708 (2) (b)(I)). The purpose of reducing the COI list based on these criteria is to focus the risk assessment on those chemicals associated with the majority of potential risk from specific areas of the Site. Where appropriate, risk screening was conducted using MTCA Method A values for residential soil. Where MTCA Method A values were not provided, EPA Region III Risk Based Concentrations (RBCs) for residential direct contact with soils was utilized (EPA, 1995). Listed below are the chemicals that were eliminated as soil COI and the associated basis for elimination:

<u>North Site</u>

- methylene chloride (common laboratory contaminant, detected at 56B ppb)

- acetone (common laboratory contaminant, detected at 88B ppb)
- benzene (detected 1/9 at 51 ppb; the detected concentration is below the MTCA Method A risk based value of 500 ppb)
- xylene (detected 1/9 at 35 ppb; below the MTCA Method A risk-based value of 20,000 ppb)

South Site

- fluorene (detected 1/11 at 110J, non-carcinogenic PAH of relatively low toxicity)
- di-n-butyl phthalate (common laboratory contaminant detected at 115J ppb)
- fluoranthene (detected 2/11 at 200J ppb; non-carcinogenic PAH of relatively low toxicity)
- butylbenzylphthalate (common laboratory contaminant detected at 300J ppb)
- pyrene (detected 2/11 at 300J ppb, non-carcinogenic PAH of relatively low toxicity)
- benzo(a)anthracene (detected 1/11 at 110J ppb; detected concentration below the MTCA method A risk based value of 1,000 ppb)
- bis(2-ethylhexyl)phthalate (common laboratory contaminant detected at 337J ppb)
- chrysene (detected 2/11 at 330J ppb; detected concentration below the MTCA Method A cleanup level of 1,000 ppb)
- di-n-octyl phthalate (common laboratory contaminant detected at 337J ppb)
- benzo(b)fluoranthene (detected 1/11 at 260J, detected concentration below the MTCA Method A cleanup value of 1,000 ppb)
- benzo(k)fluoranthene (detected 1/11 at 80J ppb; detected concentration below the MTCA method A cleanup value of 1,000 ppb)

- benzo(a)pyrene (detected 1/11 at 130J ppb; detected concentration below the MTCA Method A cleanup level of 1,000 ppb)

- indeno(1,2,3-cd)pyrene (detected 1/11 at 130J ppb; detected concentration below the MTCA Method A cleanup level of 1,000 ppb)

- benzo(g,h,i)perylene (detected 1/11 at 170J ppb; non-carcinogenic PAH of low toxicity)

- methylene chloride (common laboratory contaminant detected at 38B ppb)

- acetone (common laboratory contaminant detected at 109B ppb)

- 1,2-dichloroethane (detected 1/12 at 9 ppb; detected below EPA Region III residential soil RBC of 7 ppm)

- 2-butanone (common laboratory contaminant detected at 24 ppb)

- benzene (detected 1/29 at 93 ppb; reported concentration less than the MTCA method A cleanup level of 500 ppb)

- 1,1,2,2-tetrachloroethane (detected 1/12 at 23 ppb; detected below EPA Region III residential soil RBC of 25 ppm)

- styrene (detected 5/12 at 176 ppb; detected below EPA Region III residential soil RBC of 16000 ppm).

The final list of North and South Site soil COI to be evaluated in the risk assessment is presented in Table 11-6.

11.2.2 Sediment Data

Six sediment samples were collected along the southern bank of the South Fork of the Skykomish River (North Site sediment samples). In addition, two samples were collected in the former channel of the Maloney Creek, a seasonally dry creek bed that runs through the southern portion of the Site. These two samples are considered South Site sediment samples for the risk assessment due to their location near the facility.

Table 11-7 is a summary of the sediment samples collected and the associated parameters analyzed. The analytical methods listed in Table 11-7 are all EPA- or Ecology-approved methods.

Tables 11-8 and 11-9 provide a summary table of the analytical data for sediment samples. Metals, TPH, and VOC were detected in the samples.

The second data evaluation step involves evaluation of sample analytical detection limits. The analytical detection limits for the sediment samples ranged from:

- 0.02 to 1.5 ppm for metals
- 85 to 232 ppb for PCBs
- 365 to 47,210 ppb for SVOC
- 106 to 145 ppm for TPH (418.1)
- 5 to 58 ppb for VOC

The detection limits for SVOC compounds were elevated for several of the sediment samples. The two sediment samples from the former channel of Maloney Creek (SED-6 and SED-7) were reported to contain very low levels of TPH (less than 100 mg/kg). Because SVOC, and PAH compounds in particular, are associated with the petroleum products used at the facility, the absence of elevated TPH supports the non-detected status of the SVOC in the sediments. However, two of the samples from the Skykomish River (SED-4 and SED-5) were collected near oily seeps and contain elevated TPH (6,900 and 990 mg/kg, respectively). Given the elevated TPH, it is not possible to preclude the potential presence of PAH compounds. However, per Ecology request, PAH compounds will be addressed in the ecological risk assessment (Section 11.4).

The third evaluation step includes review of qualified or coded data. The sediment samples were qualified with standard EPA qualifiers of B and J in the reports obtained from the laboratory. Concentrations that were below the detection limit were signified with a U qualifier. The J-qualified data are acceptable for use.

The fourth evaluation step in the data validation process involved comparing the field sample data with field and laboratory blanks. Methylene chloride and acetone, common laboratory contaminants, were found in the laboratory blanks associated with almost all the sediment samples analyzed for VOC.

The fifth step in the data evaluation is further reduction of the list of chemicals of interest if the chemical is a common laboratory contaminant, has a low detection frequency, and/or the chemical is detected at low concentrations. The following chemicals were eliminated as sediment COI:

- methylene chloride (common laboratory contaminant detected at 28BJ ppb)
- acetone (common laboratory contaminant detected at 44B ppb)
- 2-hexanone (common laboratory contaminant detected at 320 ppb)

Further reduction of the COI is allowed if the maximum detected concentrations are lower than background concentrations. No sediment background samples were collected so further reduction can be performed. The final list of sediment COI to be evaluated in the risk assessment is presented in Table 11-10.

11.2.3 Groundwater Data

Four quarters of groundwater samples have been collected at the Site as part of the RI. All of the groundwater samples collected during the RI were included in the risk assessment to provide a comprehensive data set. Because the groundwater in the vicinity of the Site originates from the same aquifer, all groundwater samples are summarized together. Table 11-11 is a summary of the groundwater samples collected and the specific parameters analyzed for each sample. The analytical methods listed in Table 11-11 are EPA- or Ecology-approved methods.

Table 11-12 presents a summary of the groundwater data for the Site. Metals (dissolved and total), SVOC, TPH, and VOC were detected.

The second step in the data evaluation involves the analysis of detection limits for each parameter. The analytical detection limits for all groundwater samples ranged from:

- 0.001 to 0.01 ppm or mg/L for dissolved metals
- 0.0001 to 0.4 ppm for total metals
- 0.05 to 1 ppb for PCBs
- 0.02 to 250 ppb for SVOC
- 0.02 to 0.3 ppm for TPH (418.1)
- 0.5 to 10 ppb for VOC

The groundwater samples from well MW-28 had elevated detection limits (50 to 250 ppb) in the November 1993 sampling round; subsequent samples from that were had lower detection limits such that the data are considered acceptable. The remaining detection limits for groundwater samples are also considered acceptable for the risk assessment.

The third evaluation step includes review of qualified or coded data. The groundwater samples were qualified with standard EPA qualifiers of B and J in the reports obtained from the laboratory. Samples that were below the detection limit were signified with a U qualifier. The J-qualified data are considered acceptable for use.

The fourth evaluation step in the data validation process involved comparing the field sample data with field and laboratory blanks. Comparison of concentrations detected in the blanks with concentrations detected in the samples is common procedure and ensures that only Site-related data are used in the risk assessment. Methylene chloride and acetone were detected in four trip blanks associated with groundwater samples at concentrations of 4 to 24 µg/L and 8 to 20 µg/L, respectively. According to *Risk Assessment Guidance for Superfund* (EPA, 1989b), a chemical should be considered lab contamination if the concentration in the samples is less than 10 times that found in the blank for common lab contaminants such as methylene chloride and acetone.

The fifth step in the data evaluation is further reduction of the list of chemicals of interest if the chemical is a common laboratory contaminant (as previously discussed), has a low detection frequency, and/or the chemical is detected at low concentrations. Drinking water standards are provided where applicable for comparison to detected concentrations; in the absence of a drinking water standard a MTCA cleanup level or a general statement of relative toxicity is provided to support the elimination of a compound. Where MTCA Method A values were not provided, EPA Region III Risk Based Concentrations (RBCs) for residential ingestion of tap water was utilized (EPA, 1995). The following chemicals were eliminated as groundwater COI:

- naphthalene (detected 1/37 at 32 ppb; this non-carcinogenic PAH is relatively non-toxic)
- 2-methylnaphthalene (detected 1/24 at 200 ppb; no toxicity data are available for this compound)
- acenaphthene (detected 2/37 at 28 ppb; this non-carcinogenic PAH is relatively non-toxic)
- dibenzofuran (detected 1/24 at 19 ppb; no toxicity data exist for this compound)
- phenanthrene (detected 2/37 at 110 ppb; this non-carcinogenic PAH is relatively non-toxic)
- pyrene (detected 1/37 at 3.9 ppb; this non-carcinogenic PAH is relatively non-toxic)

- bis(2-ethylhexyl)phthalate (common laboratory contaminant detected at 3J ppb)

- di-n-octyl phthalate (detected 1/23 at 3J ppb; phthalates are common lab contaminants)

- indeno(1,2,3-cd)pyrene (detected 1/37 at 0.2 ppb; this concentration is equal to the drinking water standard established for the most potent carcinogenic PAH - benzo(a)pyrene)

- dibenz(a,h)anthracene (detected 1/37 at 0.08 ppb; this concentration is less than the drinking water standard established for the most potent carcinogenic PAH - benzo(a)pyrene)

- chloromethane (detected 1/13 at 2J ppb; detected below EPA Region III residential water RBC of 1.4 ppb)

- methylene chloride (common laboratory contaminant detected at 12B ppb)

- acetone (common laboratory contaminant detected at 10 ppb)

- chloroform (common laboratory contaminant detected at 6B ppb)

- benzene (detected 2/20 at 1J ppb, this is less than the drinking water standard of 5 ppb)

- ethylbenzene (detected 2/20 at 5 ppb, this is less than the Method A value of 30 µg/l)

Further reduction of the COI is allowed if the maximum detected concentrations are lower than background concentrations. No groundwater background samples were collected so further reduction is not necessary. The final list of groundwater COI to be evaluated in the risk assessment is presented in Table 11-13.

11.2.4 Surface Water Data

Surface water samples were collected from the South Fork of the Skykomish River (SW-4, SW-5, and SW-6), Maloney Creek (SW-1, SW-2, and SW-3), and the former channel of the Maloney Creek (SW-7). Table 11-14 is a summary of the chemicals analyzed in these samples. The analytical methods listed in Table 11-14 are EPA- or Ecology-approved methods.

Table 11-15 presents a summary of the surface water data for the Site. Chemicals were detected in only two surface water samples (SW-5 and SW-6). The only chemicals detected in those two samples were fluoranthene, TPH (as diesel), and bis(2-ethylhexyl)phthalate, a common laboratory contaminant.

The second step in the data evaluation involves the analysis of detection limits for each parameter. The analytical detection limits for all groundwater samples ranged from:

- 0.001 to 0.01 ppm for dissolved metals
- 0.0002 to 0.01 ppm for total metals
- 0.02 to 50 ppb for SVOC
- 0.02 to 1 ppm for TPH (418.1)
- 0.2 ppm for TPH as diesel

The detection limits for surface water samples are considered acceptable for the risk assessment.

The third evaluation step includes review of qualified or coded data. The surface water samples were qualified with standard EPA qualifiers of B and J in the reports obtained from the laboratory. Samples that were below the detection limit were signified with a U qualifier.

The fourth evaluation step in the data validation process involved comparing the field sample data with field and laboratory blanks. Methylene chloride and acetone were detected in four trip blanks associated with surface water samples at concentrations of 4 to 24 µg/L and 8 to 20 µg/L, respectively.

The fifth step in the data evaluation is further reduction of the list of chemicals of interest if the chemical is a common laboratory contaminant (as previously discussed), has a low detection frequency, and/or the chemical is detected at low concentrations. The following chemicals were eliminated as surface water COI:

- bis(2-ethylhexyl)phthalate (common laboratory contaminant detected at 23 ppb)

- fluoranthene (low toxicity, non-carcinogenic PAH detected 1/9 at 0.4 ppb)

Further reduction of the COI is allowed if the maximum detected concentrations are lower than background concentrations. No surface water background samples were collected so further reduction is not necessary. The only surface water COI retained for the risk assessment is TPH.

11.2.5 Summary of Site COI

The COI at the Site are chemicals that are associated with historical use of the Site, have been detected in at least one environmental media, and have undergone the data evaluation and screening process described above. Table 11-16 is a summary of the COI in groundwater, surface water, and North and South Site soil and sediment.

11.3 Exposure Assessment

The purpose of the exposure assessment is to identify all potential receptors that could be exposed to COI in soil, groundwater, surface water, and sediment at the Site. The exposure assessment identifies pathways by which humans are potentially exposed to Site COI and estimates the magnitude, frequency, and duration of actual or potential human exposures. Exposure pathways are routes whereby chemicals of interest could be assimilated by a potential receptor. Exposure pathways require the existence of a receptor, the presence of COI in a medium that the receptor contacts, and an intake route associated with the receptor. Since exposure pathways require the presence of a receptor, these pathways depend upon uses of the Site and the surrounding areas.

In the exposure assessment, reasonable maximum estimates of exposure are developed for both current and future land use scenarios. Estimates of current exposures are used to determine whether adverse health effects could arise based on the present land use of the Site. Estimates of future exposures are used to evaluate the potential for future effects and include a rationale for the likelihood that such exposures would actually occur. MTCA guidance determines the current and future land use scenarios according to the Site's current/future use and the use of the properties adjacent to the Site (i.e., industrial, residential, etc.). In order to be classified as "an industrial site" under MTCA (Ecology, 1993), all of the following criteria must be met:

- the facility must be zoned for industrial use
- the facility must be currently used for industrial purposes and has a history of industrial use
- adjacent properties must be currently used for industrial purposes
- the facility must be expected to be used for industrial purposes for the foreseeable future
- institutional controls must have been implemented in accordance with MTCA (WAC 173-340-440)

Because the adjacent properties to the BNRR maintenance and fueling facility include residential property, small businesses, and city property (i.e., public school), the Site cannot be defined as an industrial site under MTCA. Based on MTCA classifications, the residential site use must be used for the Skykomish project to represent the most reasonable maximum exposure. However, the BNRR property is clearly an industrial facility and is anticipated to remain in use as industrial facility in the future. It is inappropriate to consider residential use of the BN property due to the presence of the active, mainline railroad tracks. Thus, this analysis is inherently conservative because it is based on residential site use.

11.3.1 Scope of the Exposure Assessment

This exposure assessment has the following elements as per current MTCA (Ecology, 1993) and EPA guidance (EPA, 1989b):

- identification of potential migration pathways and receptor-specific exposure pathways
- toxicity assessment
- MTCA intake assumptions
- estimation of exposure point concentrations

A site conceptual model (Figure 11-2) was developed for the Site as a visual tool for the exposure assessment. The site conceptual model is intended to include every possible exposure to human and ecological receptors and is therefore a conservative analysis. The depiction of an exposure on this figure does not indicate that such exposures are currently occurring or that they will likely occur in the future.

The following sections discuss migration and exposure pathways and potential receptors at Skykomish, present toxicity data for the chemicals of interest, describe the intake assumptions presented in MTCA for various exposure pathways. The RI data are then used to present estimated exposure point concentrations. In a full risk assessment, the exposure point concentration would be combined with the toxicity data and intake assumptions to develop quantitative estimates of risk. Ecology has requested that this analysis not be completed for Skykomish, however, so the final risk calculations are not provided. The primary use of this analysis will be as a decision making tool in the overall remedy selection process.

11.3.2 Potential Migration Pathways and Receptor-specific Exposure Pathways

As shown in Figure 11-2, the primary sources of Site impacts resulted from historical operations at the former facility involving sandblasting activities and petroleum spills and leaks from tanks, sumps, rail cars, piping, and releases from transformers. The consequence of these activities resulted in the transfer of petroleum and other chemicals to soil, surface water and sediment (via groundwater). Potential routes whereby these chemicals could migrate from source areas in soil to other environmental media and to subsequent receptors are discussed in the following paragraphs.

Soils

Surface soils impacted by sandblasting operations and by spills or leaks of petroleum products or transformer fluids could serve as a potential source for volatiles and fugitive dusts in the ambient air. Metals and PCBs were the primary COI detected in surface soils (0-2 feet) and some petroleum stains are evident in surface soils, especially along railroad tracks. These compounds have low volatility such that the generation of organic vapors is minimal, if it occurs at all (see Section 8). Subsurface soils (2 to 15 feet bgs) could act as a potential source areas for volatile and fugitive dust emissions into the ambient air if they were exposed (i.e., during construction or excavation activities).

Site workers, area residents, and Site visitors could all potentially be exposed to COI in soils via incidental ingestion and/or inhalation of dust or volatiles. It is not likely that soil exposure would include subsurface soils unless excavation or construction activities were in progress. However, this risk assessment follows MTCA guidance, which conservatively assumes equal exposure to all soils from 0 to 15 feet bgs.

Groundwater and LNAPL

LNAPL and COI in surface and subsurface soils could serve as a potential source of groundwater contamination. COI in soil can impact groundwater via infiltration and percolation. The LNAPL is a source of groundwater contamination via dissolution and dispersion. Transport of LNAPL and other Site-related chemicals through soil to groundwater could result in the migration of these chemicals to off-Site groundwater and to nearby sediments and surface water (South Fork of the Skykomish River and Maloney Creek). Groundwater monitoring wells were installed at the Site to collect data at various depths within the groundwater plume. These monitoring wells confirmed the detection of COI and the flow of groundwater from the former maintenance and fueling facility to the South Fork of the Skykomish River. Migration of LNAPL in groundwater to the river has been observed; this discharge can be a source of surface water and sediment impacts.

Installation of interim action recovery wells to recover LNAPL near the river was completed in early 1996.

Groundwater investigations for the RI included quarterly sampling through August 1994 to characterize the extent of groundwater impacts. In order for there to be a potential risk, an exposure pathway must exist from the groundwater to a receptor (i.e., the receptor must contact the groundwater via dermal contact, ingestion, and/or inhalation of the volatiles while showering/bathing).

As was discussed in Section 2.5, the residents of Skykomish are served by two public supply water wells that are located about 1,100 feet east (upgradient) of the Skykomish city limits. These wells are completed at depths of more than 180 feet bgs and it is unlikely that COI could migrate from Site monitoring wells to the public water wells. However, this exposure assessment will conservatively assume that the impacted groundwater collected from the shallow monitoring wells is the same water used by the residents of Skykomish for drinking, cooking, and showering/bathing.

Surface Water and Sediment

The primary source of COI to surface water and sediments is via the discharge of groundwater and oily seeps. The surface water and sediment potentially impacted would be the South Fork of the Skykomish River and Maloney Creek. Stormwater runoff could also serve as a potential release mechanisms for impacted soils. Storm sewers throughout the City of Skykomish channel stormwater directly to the river and some runoff from the former maintenance and fueling facility flows toward Maloney Creek.

The only potential human receptors to surface water and sediment COI are recreational users of the river (i.e., people swimming, rafting, wading, fishing, etc.). These people could incidentally ingest surface water and sediments during the recreational activities. An additional exposure pathway is the consumption of fish which may have been impacted by surface water or sediment COI. MTCA (Ecology, 1993) evaluates this pathway by incorporating a bioconcentration factor (BCF). The BCF is the ratio of the COI concentration in fish tissue to the COI concentration in the ambient water in which the fish resides.

11.3.3 Toxicity Assessment

The purpose of a toxicity assessment is to weigh available evidence regarding the potential for chemicals of interest to cause adverse health effects in exposed individuals and to provide, where

possible, an estimate of the relationship between the extent of exposure to a chemical and the increased likelihood or severity of the adverse effect. A toxicity assessment considers:

- the types of adverse health effects associated with exposures to chemicals of interest
- the relationship between the magnitude of exposure and the adverse effects

The toxicity assessment for the Site was accomplished in two steps: hazard identification and dose-response assessment. The first step, hazard identification, is the process of determining whether exposure to an agent can cause an increase in the incidence of an adverse health effect. Hazard identification also involves characterizing the nature and strength of the evidence of causation. The second step, dose-response evaluation, is the process of quantitatively evaluating toxicity information and characterizing the relationship between the dose of the contaminant administered or received and the incidence of adverse health effects in the exposed population. From this quantitative dose-response relationship, toxicity values are derived to estimate the incidence of adverse effects occurring in humans at different exposure levels. It should be emphasized that the dose-response values discussed in this section are based on methodology that is consistent with MTCA (Ecology 1993 and 1994) and EPA risk assessment guidelines (EPA, 1989b), and is intended to be conservative and therefore, health-protective.

Toxicity Information for Noncarcinogenic Effects

The degree of toxicity of noncarcinogenic chemicals is based on the ability of organisms to repair and detoxify after exposure to a chemical. Exposure to low levels of chemicals may cause no damage as these chemicals may be readily eliminated. Higher doses of a chemical may result in cell damage that is readily repaired. This implies that a threshold exists where exposures from just above zero to some finite value can be tolerated by the organism without an appreciable risk of adverse effects. When the mechanisms of repair and detoxification are exceeded by some critical concentration, an adverse health effect(s) is manifested.

Toxic affects for noncarcinogenic chemicals are based on the reference dose (RfD) and hazard quotient (HQ). The RfD is an estimated daily dose of a chemical where no appreciable risk of chronic effects is expected to occur. The hazard quotient (HQ) is the ratio of the actual or predicted dose or intake, as calculated in the exposure assessment, and the RfD and is represented by the equation:

$$HQ = \frac{I}{RfD}$$

where: I = amount of medium ingested or inhaled per day or intake (mg/kg/day)

RfD = Reference Dose (mg/kg/day)

The hazard index (HI) is the sum of the hazard quotients:

$$HI = HQ_1 = HQ_2 = HQ_3 ... HQ_n$$

The HI approach assumes that simultaneous subthreshold exposures to several chemicals could result in an adverse health effect. It also assumes that the magnitude of the adverse effect will be proportional to the sum of the ratios of the subthreshold exposures to acceptable exposures.

RfDs are expressed primarily according to the length of exposure being evaluated and the intake pathway. A chronic RfD is an estimate of a daily exposure level for the human population, including sensitive subpopulations, that is likely to be without an appreciable risk of damaging effects during a lifetime. Chronic RfDs are specifically developed to be protective of long-term exposure to a chemical (generally associated with exposure periods between seven years and a lifetime). A subchronic RfD accounts for noncarcinogenic effects associated with shorter term exposures.

Uncertainty factors are used in calculating an RfD. These factors reflect scientific judgement regarding the various types of data used to estimate RfD values. An uncertainty factor of 10 is generally used to account for variations in human sensitivity. An additional 10-fold factor is generally used for each of the following extrapolations: from long-term animal studies to humans, from a LOAEL (the lowest observed adverse effect level) to a NOAEL (the no observed adverse effect level), and from subchronic studies to a chronic RfD. In order to reflect professional assessment of the uncertainties of the study and database not explicitly addressed by the above uncertainty factors, an additional uncertainty factor or modifying factor ranging from greater than 0 to less than or equal to 10 is applied. The default value for this modifying factor is one (HEAST, 1994).

Toxicity Information for Carcinogenic Effects

Cancer is the end result of a multistage process in which a large number of biological and environmental factors interact, simultaneously or in sequence, to disrupt normal cell growth and division (Rich, 1990). For chemicals which potentially cause or increase cancer incidence, the results of high-dose animal studies are extrapolated to low-dose human exposure scenarios using mathematical models. The EPA has chosen a linear, multistage risk assessment model, which assumes that if any dose of a toxic substance increases one's risk for cancer, then every dose can increase the cancer risk in equal proportion. This model assumes safe exposure levels do not exist for carcinogens. This is contrary to the traditional approach to toxic chemicals, in which finite thresholds are said to exist, below which the toxic effect will not occur because humans possess protective biological mechanisms. This traditional approach is still applied to noncarcinogenic chemicals and because of the differing approaches, the risks associated with carcinogenic effects are generally much higher than those associated with the noncarcinogenic effects.

Based on available data, the EPA uses a weight-of-evidence approach to classify the likelihood of a chemical to cause cancer. The EPA carcinogen classification system uses the following sources as criteria in their determination of potential carcinogens: data from studies on the association between human cancer incidence and exposure; long-term animal studies conducted under controlled laboratory settings; short-term tests for genotoxicity, metabolic, and pharmacokinetic properties; toxicological effects other than cancer; structure-activity relationships; and physical/chemical properties of the chemical (EPA, 1986b). The weight-of-evidence classification and cancer slope factor are the toxicity data most commonly used to evaluate potential human carcinogenic risks. The carcinogenic potential of a chemical is classified into one of the following classes, according to the weight-of-evidence from epidemiological and animal studies:

- Class A — Human carcinogen
- Class B — Probable human carcinogen (B1 - limited evidence of carcinogenicity in humans; B2 - sufficient evidence of carcinogenicity in experimental animals with inadequate or lack of evidence in humans)
- Class C — Possible human carcinogen (limited evidence of carcinogeni- city in experimental animals or lack of human data)
- Class D — Not classifiable as to human carcinogenicity (inadequate or no evidence)
- Class E — Evidence of noncarcinogenicity for humans (no evidence of carcinogenicity in adequate studies)

At low doses, the probability of contracting cancer in a lifetime is assumed to be proportional to the cumulative lifetime dose. The coefficient relating dose to risk is called the cancer slope factor (CSF) or the cancer potency factor (CPF). Thus, if the dose or intake is represented by I and the cancer potency factor by CPF, then the risk (R), is given by the equation:

$$\text{Risk} = CPF \times I$$

The intake has units of mg/kg-day and represents the average daily intake over the lifetime of the exposed individual. The cancer potency factor is actually the upper bound value based on fitting a mathematical model to experimental dose-response data. The cancer potency factor is used to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular chemical. Cancer potency factors, which have units of $(\text{mg/kg-day})^{-1}$.

Summary of Toxicity Data for Chemicals of Interest

Table 11-17 is a summary of the noncarcinogenic reference doses (RfDs), the carcinogenic cancer potency factors (CPFs), and the bioconcentration factors (BCFs) for the COI at the Site. These toxicity values were obtained from MTCA guidance (Ecology, 1994). Most of these toxicity values were derived from IRIS, HEAST, ECAO (EPA's Environmental Criterion and Assessment Office), EOTS (EPA's Office of Toxic Substances), or EPA Region X.

There are several COI for which noncarcinogenic and carcinogenic toxicity data are currently not available. These chemicals were denoted with "ND" in Table 11-17 and include the following chemicals:

- lead
- 2-methylnaphthalene
- phenanthrene
- TPH

11.3.4 MTCA Intake Assumptions

This section describes the assumptions used for calculating the intake by potential receptors at the Site. These intake assumptions consider the number of times a receptor is expected to contact a particular medium, the duration of the contact, and the mechanisms that enable the chemical to be potentially assimilated by the receptor. The intake assumptions presented in this section are intended to approximate reasonable maximum exposures (RMEs) and are based on the MTCA guidance (Ecology, 1993 and 1994). The intake assumptions vary according to the classification

of the Site (industrial or residential) and the MTCA method used to calculate the cleanup level (Method A, B, or C). MTCA provides three methods for establishing site-specific cleanup levels:

- Method A defines cleanup levels for 25 common site chemicals and is designed for routine cleanups.

- Method B determines cleanup levels at sites (unless Method A or Method C is more appropriate) using a site-specific risk assessment with risk levels established at 10^{-6} for individual carcinogens and 10^{-5} for total site risk.

- Method C determines cleanup levels for specific site uses (i.e. industrial) using site-specific risk assessment when Method A and B levels are technically impossible to achieve (using 10^{-5} risk levels for both individual carcinogens and total site risk).

Method A does not apply to the Site because groundwater cleanup is not considered to be a "routine cleanup" as defined by MTCA (WAC 173-340-130). Method B and Method C apply to this Site. These methods are similar with the exception of risk level and various media-specific intake assumptions. Method B carcinogenic risk levels are one in a million or 10^{-6}, whereas Method C carcinogenic risk levels are one in 100,000 or 10^{-5}. The intake equations and assumptions are presented for each method by media:

- Soil Method B - Table 11-18
- Soil Method C - Table 11-19
- Groundwater Method B - Table 11-20
- Groundwater Method C - Table 11-21
- Surface Water Method B - Table 11-22
- Surface Water Method C - Table 11-23
- Air Method B - Table 11-24
- Air Method C - Table 11-25

MTCA guidance does not provide risk-based cleanup levels for sediment, however, the ecological risk assessment (Section 11.4) does evaluate sediment COI.

11.3.5 Exposure Point Concentrations

Exposure point concentrations are used in risk assessment to define the concentrations of COI in various media that receptors can be exposed to. Procedures for developing exposure point concentrations have been developed in detail by EPA. These procedures include use of direct measurement at a point of contact and/or modeling of chemical release and transport to the point of

contact (exposure point). This risk assessment will use direct measurements at the point of assumed contact for exposure to soil, groundwater, surface water, and sediment. A simple model was also used to estimate the concentration of COI in air due to particulate emission and volatilization of soil COI (see Section 8 and Appendix J). It is conservatively assumed that the exposure point concentrations are constant in all media for the duration of exposure. This means that the natural physical, chemical, or biological processes which reduce chemical concentrations over time and space are not considered. Consequently, using only the measured concentration of the chemical in a particular medium to calculate potential risks is highly conservative.

Exposure point concentrations were estimated for COI in soil, groundwater, surface water, and sediment by using the lower of either the 95% upper confidence level on the arithmetic mean or the maximum detected concentration (EPA, 1989b). The statistical analysis takes into consideration hot spot concentration while recognizing that long-term, exposures (e.g. those defined by MTCA under the residential land use scenario) would not be limited exclusively to those hot spots. Tables 11-26 through 11-31 summarize the soil (North and South Site), sediment (North and South Site), groundwater, and surface water exposure point concentrations (the "normal source concentration" in the tables). Table 11-32 is a summary of the calculated air concentrations using the models discussed in Section 8 and Appendix J.

11.4 Ecological Evaluation

Ecological risk assessment is defined as "a process that evaluates the likelihood that adverse ecological effects are occurring or may occur as a result of exposure to one or more stressors." A stressor, as defined by EPA, is "any physical, chemical, or biological entity that can induce an adverse ecological response." An ecological risk assessment attempts to establish the causal link between site COI and specific adverse ecological effects (EPA, 1992).

This assessment will focus on potential adverse effects of Site COI in sediment and surface water to aquatic and benthic organisms associated with the South Fork of the Skykomish River and the Maloney Creek. Literature data were reviewed and a site walk-through was conducted with Ecology representatives to help define the appropriate scope of this assessment. No other field work was conducted solely for the purpose of the ecological assessment. Note that recovery wells were installed in late 1995 to reduce the migration of petroleum product in groundwater to the South Fork of the Skykomish River. The impact of this interim action recovery system has not been considered in this evaluation.

The ecological risk assessment approach used in this section follows EPA's *Framework for Ecological Risk Assessment* (EPA, 1992) and includes the following subsections:

- Actual and Potential Receptors (11.4.1)
- Actual and Potential Exposure Pathways (11.4.2)
- Risk Characterization (11.4.3)

This ecological risk assessment is primarily a qualitative screen of the potential risks to ecological receptors from chemicals of interest (COI) detected in the sediment and surface water samples at the Site. Metals and TPH were the only COI detected in surface water and sediments. Although not detected, PAH were conservatively added to the ecological evaluation as sediment COI due to high detection limits in several samples. Site soil data were examined to help assess the potential for PAH to be present in river sediments. PAH were detected in soil samples from four locations. One compound (phenanthrene) was identified in boring B-4, three were identified in B-6 and DW-2 and nine were identified in MW-39. Based on these data, an artificial sediment PAH was derived for the purpose of ecological analysis using the PAH concentrations detected in soil from location MW-39. This location was selected for this purpose because it had the greatest number of individual PAH compounds detected. Further, this sample had the highest total PAH of the three samples with multiple compounds detected. Table 11-33 is a summary of these PAH concentrations in addition to the surface water and sediment COI exposure point concentration (i.e., the 95% upper confidence limit on the arithmetic mean or the maximum detected concentration, whichever is lower).

11.4.1 Actual and Potential Receptors

An important step in the ecological risk assessment process is the identification of key species and habitats. These may include economically important species, species that have special regulatory status (such as threatened or endangered species), or ecologically critical species and their associated habitats.

An extensive search was conducted to identify the key species present in the vicinity of the Site. Three databases developed by the Washington Department of Wildlife were accessed to obtain this information. The following three databases provide comprehensive information on the locations of important fish and wildlife:

- Nongame Heritage Database contains significant site observations of nongame species of concern, including federal and state listed species.

- Priority Habitats and Species is an inventory of key species use areas and key wildlife habitats, including the locations of federal and state listed species (threatened, endangered, sensitive, candidate) and other priority nongame and game species.

- Washington Rivers Information System is a statewide inventory of all anadromous and resident fish distribution, including priority, federal, and state listed species.

Data was compiled from these three databases for an area encompassing nine square miles around the Site in an attempt to focus the information search. The following paragraphs discuss the results of the database search. Although the search was narrowed to nine square miles surrounding the Site (i.e., search area), it is not likely that the key species identified would be located at the Site in the City of Skykomish when the Mt. Baker - Snoqualmie National Forest surrounds the town. This is in fact the case, as none of the sensitive species or habitats identified by the Washington Department of Wildlife databases (and summarized below) were located within the Site boundary.

The Nongame Heritage Database identified the following key species within a nine square mile area of the Site:

- Spotted Owl - state and federally endangered species
- Bald Eagle - state and federally threatened species
- Northern Goshawk - state and federal candidate species
- Marbled Murrelet - state and federally threatened

The Priority Habitats and Species database search resulted in the identification of two species and their associated habitats located within the nine square mile search area. The Harlequin Duck, a federal candidate species, is one of these species whose breeding ground is located within the search area. The specific breeding areas were Skykomish River, Money Creek, and Beckler River. Skykomish River North was identified as a priority habitat because it is the wintering range of the Mountain Goat.

The Washington Rivers Information System database classified the South Fork of the Skykomish River and the Maloney Creek as:

- critical spawning habitats for resident species
- anadromous fish runs
- listed resident fish runs

Because these classifications pertain to surface water bodies adjacent to the Site (i.e., South Fork of the Skykomish River and Maloney Creek), fish inhabiting these water could potentially be exposed to surface water and sediment COI. Benthic invertebrates and aquatic organisms (other than fish) inhabiting these waters could also be included as potential receptors in the ecological risk assessment.

11.4.2 Actual and Potential Exposure Pathways

It is important to identify complete exposure pathways prior to evaluation of toxicity to focus the assessment only on those COI that can reach ecological receptors. A complete exposure pathway is one in which the chemical can be traced from the source to the receptor being evaluated. If receptors cannot be exposed to a COI, the exposure pathway does not need to be evaluated. In this section, potential exposure pathways for ecological receptors are identified for surface water and sediment.

Previous Site investigations have identified the presence of petroleum product seeping into the South Fork of the Skykomish River. Because there is a measurable LNAPL thickness on the groundwater at the facility, it is likely that LNAPL and impacted groundwater from historical facility operations migrated downgradient to the river.

Groundwater that carries LNAPL and COI may be discharged to surface water and, depending on the pattern of groundwater flow, this may occur near or far from the source of the COI. Most of the groundwater from the facility flows toward the South Fork of the Skykomish River, so this pathway could lead to exposure of aquatic or benthic organisms in the river. These environmental receptors may contact it directly or via the sediment. Surface water and sediment samples were collected from the South Fork of the Skykomish River, Maloney Creek, and the former channel of the Maloney Creek (Section 7.0). Metals and TPH were the only COI detected in these samples. PAH were not detected in sediments but were included in the ecological risk assessment. Petroleum sheens have been observed near the location of oily seeps that have been identified under low river flow conditions (Figure 6-12).

11.4.3 Risk Characterization

The purpose of the risk characterization step is to determine if potential risks are or could be occurring to ecological receptors exposed to Site COI in sediment and surface water. Concentrations of the sediment and surface water COI are compared to benchmark concentrations which are concentrations of chemicals that result in no adverse effects to ecological receptors. The

ecological risk is determined by the simple ratio (the exposure effects ratio or EER) of the COI exposure point concentration to the benchmark concentration.

$$EER = \frac{CONC}{BENCH}$$

The EER does not consider variability in either exposure (CONC) or effects (BENCH) and thus does not represent a statistical probability of occurrence of adverse ecological effects. It is strictly a screening tool used to decide if there is no significant risk or that further evaluation may be required.

Menzie, et al. (1993) suggested EER be interpreted in the following manner:

- EER < 1 indicates no significant risk
- 1 < EER <10 indicates small potential for ecological effects
- EER >10 indicates some potential for ecological effects
- EER >100 indicates ecological effects very probable

Environmental Benchmarks

Environmental benchmarks are typically determined by using ARARs (applicable or relevant appropriate requirements). These include EPA's National Ambient Water Quality Criteria (NAWQC) for the protection of organisms in freshwater or marine water bodies or Sediment Quality Criteria (SQC) for the protection of organisms in sediment associated with those water bodies. Ecology has published a *Summary of Criteria and Guidelines for Contaminated Freshwater Sediments* (Ecology, 1991); however, none of the sediment or surface water COI from the Site were included in the summary. Other published benchmarks (NAWQC and SQC) were available for most sediment COI. The focus of the remainder of the ecological risk assessment will therefore be receptors exposed to COI (metals and PAH) in sediment.

Sediment benchmark concentrations for metals were determined based on the review of sediment toxicity tests by Long and Morgan for the National Oceanic and Atmospheric Administration (Long and Morgan, 1990). The reports, *The Potential for Biological Effects of Sediment-sorbed Contaminants Tested in the National Status and Trends Program* (Long and Morgan, 1990) and *Incidence of Adverse Biological Effects within Ranges of Chemical Concentrations in Marine and Estuarine Sediments* (Long et al., 1994), are a review of chemical and biological data from over 200 sites nationwide assessing the relative likelihood or potential for adverse effects to occur due to exposure of biota to chemicals in sediment. These reports have been used by the EPA and several state and regional agencies to derive sediment quality criteria.

For each chemical, data from the appropriate studies (Long et al., 1994) were arranged in ascending order of concentration and distributions of the effects data were determined using percentiles. Two values were derived for each chemical:

- Effects Range-Low (ER-L): the lower 10th percentile of the effects data
- Effects Range-Median (ER-M): the 50th percentile of the effects data

These two values represent three concentration ranges for each chemical. The concentrations below the ER-L value represent a minimal-effects range or a range intended to estimate conditions in which effects would be rarely observed. Concentrations equal to and above the ER-L, but below the ER-M in sediment, represent a possible-effects range within which effects would occasionally occur. And concentrations equal to or above the ER-M value represent a probable-effects range or a range in which effects would frequently occur. The ER-L and ER-M values for the COI are compared to the exposure point concentrations of sediment COI in Table 11-34. ER-M values are more appropriate benchmark concentrations since the objective of the benchmark concentration is to estimate a chemical concentration at or above which possible effects occur as opposed to effects which would rarely be observed. Apparent effect threshold (AET) criteria was included for sediments. An AET concentration is the sediment concentration of a selected concentration of a selected chemical above which statistically significant biological effects always occur. Ecology used the sediment quality triad approach to develop AETs to derive sediment quality criteria. These AET sediment values are summarized in Table 11-34.

Also included (at the request of Ecology) were lowest effect levels for sediment COI. The lowest effect level is the level at which actual ecotoxic effects become apparent. These criteria were developed by the Ontario Ministry of the Environment (1990) and are included in Table 11-34.

Exposure Effects Ratio

The ecological risk in this screening level assessment is determined by a simple ratio of the exposure point concentration (estimated exposure) to the benchmark for toxicity for each sediment COI. This ratio is termed the exposure effects ratio (EER). If the ratio of predicted exposure to benchmark toxicity (the EER) is less than one (exposure is less than the toxicity benchmark), then no significant ecological risk is inferred. If the exposure equals or exceeds the toxicity benchmark, then the screening level assessment cannot exclude the possibility that there is a potential ecological risk from that COI.

As noted previously, aquatic and benthic communities are the focus of this assessment because these were identified as the receptors potentially exposed to impacted sediment in the South Fork of the Skykomish River and Maloney Creek. Food chain impacts, i.e., considering impacts on predators of aquatic and benthic organisms, were not considered in this assessment. However, the benchmarks chosen reflected multiple species and community responses, and are therefore protective of these species.

Tables 11-35 and 11-36 summarize the North Site sediment exposure effects ratios (exposure point concentrations from the South Fork of the Skykomish River and Maloney Creek sediment COI compared to their benchmark concentrations) for total metals and TPH (Table 11-35) and hypothetical PAH (Table 11-36). No sediment quality criteria is available for TPH, so an EER could not be developed for that COI. For total metals in the North Site sediments (Table 11-35) all of the EERs for ER-M and AET values were less than 1, indicating no significant ecological risk exists from the concentrations of metals in sediments. Arsenic, chromium, copper, lead, and nickel EERs exceeded 1 (but were less that 10) for the ER-L and lowest effect level criteria, indicating that there is a small potential for ecological effects. There were no EERs greater than 1 for the hypothetical PAH in the North Site sediments (Table 11-36), signifying no potential for ecological risk.

Table 11-37 is a summary of the EERs for total metals and TPH in South Site sediments. No COI EERs exceeded 1 for the ER-L and AET criteria. EERs for only three metals (arsenic, chromium, and nickel) exceeded 1 for ER-L and lowest effect level criteria. However, all of these exceedances were less than 10, indicating that a small potential for ecological effects exists from these COI.

12.0 REMEDIAL GOALS AND OBJECTIVES

MTCA provides the framework for evaluating and selecting cleanup actions. This framework includes threshold requirements that must be met by all cleanup actions. The threshold requirements for remedial actions are defined at WAC 173-340-360(2) as follows:

> "All cleanup actions...shall protect human health and the environment; shall comply with cleanup standards; shall comply with applicable state and federal law; and shall provide for compliance monitoring."

Other requirements for cleanup actions, as identified in WAC 173-340-360(3), are to use permanent solutions to the maximum extent during the public comment practicable, to provide for a reasonable restoration time frame and to consider public concerns raised on the draft cleanup action plan.

Where a cleanup action results in leaving contaminants in place at levels that exceed cleanup standards, institutional controls and monitoring are required under MTCA, WAC 173-340-410, -440. Institutional controls are measures taken to limit or prohibit activities that may interfere with a cleanup action, and they include such measures as deed restrictions. If necessary, BNRR will develop appropriate deed restrictions for property that it owns. Deed restrictions on property not owned by BNRR would be subject to the property owner's discretion.

The purpose of this section of the RI report is to develop cleanup standards for the Site that are protective of human health and the environment and to define the state and federal laws that are applicable to the Site or to potential cleanup actions that may be taken at the Site. Under MTCA, determination of cleanup standards requires that both cleanup levels and points of compliance be defined. Each of these is discussed below, followed by presentation of the cleanup standards and applicable state and federal laws. The feasibility study (FS) report will identify and evaluate alternative means of achieving Site cleanup. The FS will address the permanency of various alternatives, discuss restoration time frames and present any public concerns identified during the overall RI/FS process.

12.1 Cleanup Levels

Cleanup levels under MTCA are defined as the concentrations of hazardous substances that are protective of human health and the environment under specified exposure conditions. The relevant hazardous substances were identified in Section 11 of this RI report for soil, sediment,

groundwater and surface water. Section 11 also discussed the specific exposure conditions associated with two of the cleanup options available for the Site (MTCA Methods B and C). The third cleanup option, Method A, consists of tabulated values and is appropriate for routine cleanup actions or for sites with only a few hazardous substances (WAC 173-340-700(3)(a)). Method A does not apply to the Site because groundwater cleanup (underway as interim action) is not considered to be a routine cleanup action (WAC 173-340-130(7)(c)).

The Method B and Method C approaches to developing cleanup levels are similar but they use different "acceptable" risk levels and slightly different exposure assumptions. Under MTCA, Method B is the standard method and is applicable to all sites. The applicability of Method C is limited to sites where one or more of the following conditions exist (WAC 173-340-706):

1. Method A or Method B cleanup levels are below the area background concentrations
2. attainment of Method A or Method B cleanup levels has the potential to pose a greater risk than attainment of Method C cleanup levels
3. attainment of Method A or Method B cleanup levels is not technically possible
4. the Site is defined as an industrial site under MTCA

The first two conditions are not applicable to the Site. The latter two conditions could be to determined to be applicable during development of cleanup levels and/or preparation of the FS. For this reason, both Method B and Method C cleanup levels will be developed for the hazardous substances at the Site.

MTCA also requires that the Method B and Method C cleanup levels for each media be at least as stringent as the concentrations established under applicable state and federal law. The applicable standards for each media will be identified in the following sections.

12.1.1 Groundwater

Several aspects of groundwater use must be considered to ensure that the selected cleanup levels are protective of human health and the environment. Cleanup levels that protect people who use groundwater as their routine drinking water supply can be calculated using MTCA Method B or Method C and can be evaluated by considering the drinking water standards established by EPA and the state Health Department. For sites where groundwater discharges to surface water, MTCA also includes procedures for calculating cleanup levels that are protective of humans who may eat fish caught from the surface water. These procedures are the MTCA Method B and Method C

surface water cleanup levels. EPA has also established ambient water quality criteria to protect humans who eat fish or shell fish. Finally, both EPA and Ecology have established standards and criteria that are designed to protect aquatic life. Selection of groundwater cleanup levels for this Site will consider both groundwater as a potable supply source and groundwater as a source of recharge to surface water.

Table 12-1 summarizes Site groundwater quality data (exposure point concentration from Chapter 11) and provides drinking water standards, the Method B and Method C cleanup levels for groundwater based on potable use, EPA ambient water quality criteria to protect aquatic life and to protect people who eat fish and shellfish, the state surface water standards to protect aquatic life and the Method B and Method C surface water cleanup levels based on protection of human health. The final column of Table 12-1 is the lowest of the various standards and criteria for each compound - the lowest level is the selected cleanup level in accordance with MTCA requirements.

Site groundwater quality data was then compared to these cleanup levels to define those compounds in groundwater that exceed cleanup levels. Note that the Site groundwater quality data for a few metals (arsenic, chromium and lead) includes both total and dissolved concentrations. The remaining metals were measured as totals only. The total concentrations are obtained from laboratory analysis of unfiltered groundwater samples that contain solids. The dissolved concentrations are obtained from laboratory analysis of samples that were filtered to remove solids before analysis. The Site data shows that metal concentrations in groundwater are reduced significantly (by greater than 95% on average) when the solids are removed. Therefore, analytical results for total (unfiltered) samples reflect metals that are associated with the solids in addition to the metals that are actually dissolved in groundwater.

When dissolved metal concentrations are considered, only one metal, arsenic, exceeds MTCA cleanup levels. Dissolved arsenic is above the Method B and C cleanup levels for both groundwater and surface water. However, dissolved arsenic does not exceed the drinking water standard. When total metal concentrations are considered, the Site groundwater concentrations of seven metals exceed cleanup levels. These are metals are arsenic, chromium, copper, lead, mercury, nickel and zinc. Five of these metals (chromium, copper, lead, mercury and zinc) exceed the ambient water quality criteria or the surface water standards. However, none of these metals were even detected in actual surface water samples collected from the Site. Therefore, although the Site groundwater contains some metals above protective levels for surface water and hence has the *potential* to adversely impact surface water quality, no such impact has been measured. Because the Site conditions have been stable for some period of time (i.e., railyard facility operations ceased

about 20 years ago), it is unlikely that groundwater impacts to surface water quality will increase in the future.

Two semivolatile organic compounds were detected in groundwater above MTCA Method B and C cleanup levels for groundwater and surface water. These compounds, benzo(a)anthracene and chrysene, are both carcinogenic PAHs and were detected infrequently. The detected concentrations of benzo(a)anthracene and chrysene also exceed the proposed MCL for these compounds. TPH concentrations in groundwater at the Site exceed the only available standard or criteria - the MTCA Method A value of 1 mg/l. This value is not a risk-based value but was developed to protect the aesthetics of a water supply (i.e., to prevent objectionable taste or odor; WAC 173-340-720 (2)(a)(I) v). One volatile organic compound, 1,1-dichloroethene, was detected in a groundwater sample at a concentration above the MTCA Method B and C groundwater cleanup levels. The detected concentration is below the drinking water standard established for this compound.

12.1.2 Soil

Soil cleanup levels serve a dual function under MTCA. First, the soil cleanup levels define the concentrations that are protective of humans who may be in direct contact with those soils. Second, because compounds can leach from soil and impact groundwater, MTCA also includes procedures for defining soil cleanup levels that are protective of groundwater quality.

Table 12-2 presents Site soil quality data (exposure point concentrations from Chapter 11), natural background concentrations, residential cleanup levels for soil using MTCA Methods A, B and C and soil cleanup levels based on groundwater protection. As defined in MTCA, Method A values "provide conservative cleanup levels for sites undergoing routine cleanup actions or those sites with relatively few hazardous substances." Method A cleanup values are not considered by BN to be applicable to Skykomish but are included in Table 12-2 at the request of Ecology. Method B and C cleanup levels are calculated using conservative assumptions selected by Ecology to be protective of human health under a residential land use scenario. Table 12-2 includes soil cleanup levels calculated in accordance with MTCA by multiplying the groundwater cleanup levels specified in Table 12-1 by a factor of 100. The intent of this step is to ensure that the selected soil cleanup levels are protective of groundwater because constituents can leach from soil into groundwater. The last column of Table 12-2 presents the selected soil cleanup levels for the Site.

MTCA acknowledges that it is not feasible to achieve cleanup levels that are below the natural background concentration. MTCA therefore specifies that when Method A or B cleanup

levels are below background, then either the background concentration or the Method C concentration is the appropriate cleanup level (WAC 173-340-706 (1)(a)). All of the soil cleanup levels for metals that were determined by multiplying the groundwater cleanup level by 100 were found to be below the natural background concentration. Since it is not possible to clean up soil to values less than background concentrations, this approach for development of soil cleanup levels is not applicable to metals at the Site. Therefore, Method B cleanup values for metals in soil will be used. However, the Method B cleanup levels for arsenic, beryllium and cadmium are also below the natural background concentration. In accordance with MTCA procedures, the cleanup levels for these metals have been set equal to the Method C cleanup value.

No Method B or C cleanup levels can be calculated for lead because of the lack of toxicity data for this metal. Ecology has established Method A cleanup levels for lead at 250 mg/kg for residential land use and 1,000 mg/kg for industrial land use. EPA (1994b) has established a soil action level of 400 mg/kg lead for residential property. As shown in Table 12-2, the Site soils exceed the Ecology Method A cleanup level for lead in residential soil. Neither the Method A cleanup level for lead in industrial soil nor the EPA action level for lead are included in Table 12-2 but they are referenced herein as potential action levels.

Soil cleanup levels for organic compounds are either equal to the Method B (PCBs) or Method A (TPH and volatile organics) values. Note that the Method A values for TPH in soil are based on 100 times the Method A groundwater cleanup level (if the TPH is in the form of gasoline) or 200 times the groundwater cleanup levels (for diesel and other fuel oils). In doing this, Ecology recognized that diesel fuel was less mobile and less water soluble than gasoline. No cleanup levels can be developed for the two semivolatile organics that were selected as constituents of interest in soil; there is insufficient data with which to calculate Method B or Method C values, Method A values have not been designated by Ecology and groundwater cleanup levels were not applicable to these two compounds.

Comparison of Site soil quality data to cleanup levels indicates that lead, PCBs and TPH are the constituents present in soil above cleanup levels.

12.1.3 Sediment

MTCA does not yet include provisions for determining sediment cleanup levels under methods A, B or C. Cleanup levels are therefore not tabulated as they were for groundwater and soil. The ecological assessment presented in Section 11.4 indicated that the compounds detected in the RI sediment samples are present in concentrations that are protective of aquatic life. No PAH

were detected in the RI sediment samples. However, a hypothetical sediment PAH was evaluated based on measured soil PAH concentrations. This conservative analysis did not indicate that sediments would assumed to be present at one-half the maximum reported detection limit, then a potential adverse impact could be realized. Ecology develops sediment cleanup levels on a case-by-case basis; BN does not consider sediment cleanup levels to be necessary for Skykomish because of the low risks associated with the detected metals and the lack of detectable PAH. Measures to prevent or reduce the seasonal seepage of LNAPL to the river will be evaluated in detail in the feasibility study .

12.1.4 Surface Water

One of the surface water samples collected during the RI contain a detectable compound - TPH. There is no basis from which to calculate surface water cleanup levels for TPH and no numeric surface water standards or criteria have been established by EPA or Ecology specifically for TPH. For these reasons, surface water cleanup levels are not tabulated for Skykomish. As was mentioned above, the feasibility study will evaluate measures to prevent or reduce the seasonal seepage of LNAPL to the river.

12.1.5 Air

Table 12-3 presents the calculated air cleanup levels using Method B and Method C. There are no applicable state or federal standards for the concentrations of these compounds in ambient air. The calculated air concentrations based on potential air emissions from soil (see Section 8 and Appendix J) are included in Table 12-3 for comparison. All estimated site concentrations are below cleanup levels.

12.1.6 Summary and Delineation of Areas above Cleanup Levels

MTCA requirements and Ecology guidance was followed to develop cleanup levels for groundwater, soil and air at the Site. Surface water and sediment cleanup levels could not be established within this framework given the available data. Samples of soil and groundwater collected from the Site exceed some of these cleanup levels. Figure 12-1 depicts the areas where cleanup levels are exceeded and delineates the boundaries of the Skykomish “Site”.

12.2 Points of Compliance

Points of compliance for the Skykomish Site are described below for soil and groundwater. Points of compliance are the locations where cleanup levels will be applied. No points of compliance are presented for sediment, surface water or air because: 1) no sediment cleanup levels are available using MTCA methods, 2) there is no basis for establishing surface water cleanup levels for TPH, the only compound that was detected in the surface water samples, and 3) the estimated air concentrations are below the applicable cleanup standards.

12.2.1 Soils

WAC 173-340-740(6) provides the factors to be considered in establishing a point of compliance for soil. The point of compliance for soil can vary depending on the basis for the soil cleanup levels. For soil cleanup levels based on protection of human health via direct contact, the point of compliance is defined as the upper 15 feet of soil throughout the Site. Ecology believes that this represents a reasonable estimate of the maximum depth at which soils could be excavated and placed at the surface. Given the relatively shallow depth to groundwater at Skykomish, this represents a very conservative point of compliance for the Skykomish Site.

When soil cleanup levels are based on protecting groundwater quality, MTCA defines the point of compliance as all of the soil at the Site. Because all of the soil cleanup levels based on protection of groundwater were below background concentrations, these values were not used in selected soil cleanup levels for Skykomish. The selected Skykomish soil cleanup levels are either based on Method B or C values for protection of human health or are published Method A cleanup levels (lead and TPH). Because groundwater is encountered within the upper 15 ft at the site, use of a 15 ft compliance depth is protective of groundwater and is in accordance with MTCA. Extending the point of compliance beyond 15 ft (i.e., to depths well below the depth of groundwater) would not provide additional protection.

12.2.2 Groundwater

MTCA defines the point of compliance for groundwater at cleanup site as "throughout the site from the uppermost saturated zone extending vertically to the lowest most depth which could potentially be affected" (WAC 173-340-720(6)(b)). MTCA also states that where hazardous substances will remain at a cleanup site, a "conditional point of compliance" may be established. A conditional point of compliance is to be located as close as practicable to the source of the hazardous substance and should not exceed the property boundary.

The LNAPL at Skykomish is defined as a hazardous substance under MTCA. The LNAPL is a recognized source of the groundwater contamination at the Site. Removal of all of the subsurface LNAPL is considered to be technically impossible due to: 1) the presence of permanent structures over most of the area of LNAPL occurrence and 2) the relatively viscous nature of the LNAPL. Therefore, some residual LNAPL will be remain at the Site indicating that a conditional point of compliance is appropriate.

The proposed conditional point of compliance for groundwater at the Skykomish Site is the defined as the area that extends from the LNAPL plume to the outer boundary of the dissolved plume. This point of compliance is as close as practicable to the source in accordance with WAC 173-340-720(6)(c). Existing monitoring wells that lie within this defined point of compliance include downgradient or cross-gradient wells MW-16, MW-19, MW-37 to the west of the LNAPL and MW-35 and DW-5 to the east of the LNAPL.

Because groundwater discharges to the Skykomish River and oily seeps have been noted at some locations along the river bank, an additional groundwater point of compliance can be established within the river. As per WAC 173-340-720(6)(d), such a point of compliance should be established as close as technically possible to the point where groundwater flows into the surface water. The surface water sampling locations used in the RI meet that definition and will be retained as additional points of compliance.

12.3 Cleanup Standards

The cleanup standards for the Skykomish Site are now developed by assigning cleanup levels to points of compliance. These standards are provided in Table 12-4 for soil and groundwater.

12.4 Other Regulatory Requirements

Cleanup actions under MTCA must demonstrate compliance with other state and federal laws that are applicable to the Site or to the cleanup actions that are proposed. The requirements of these laws are applicable for several different reasons. Some laws may be applicable because the law regulates the concentrations of the hazardous substances present at the Site (e.g., MCLs). These are referred to as chemical-specific requirements and were presented with the discussion of media specific cleanup levels in Tables 12-1 through 12-3. Other laws may be applicable because they establish standards for the type of cleanup action that may be implemented (e.g., water discharge

requirements) or for the general Site setting (e.g., wetland protection requirements). These latter items are referred to as action-specific and location-specific requirements. Table 12-5 provides a list of potentially applicable location- or action-specific laws and identifies those that are or may be applicable to this project.

13.0 IDENTIFICATION AND DISCUSSION OF DATA GAPS

The distribution of contaminants in soil, groundwater, surface water and sediment is presented in detail in earlier sections of this report. The combination of previous investigations and the RI have resulted in a comprehensive database for the Site including analytical, physical, stratigraphic and hydrogeologic data. These data, along with the upcoming interim product recovery activities, are adequate to enable the identification and evaluation of remedial alternatives for the Site during the FS. These remedial alternatives will be selected and assessed in terms of their ability to satisfy the remedial goals and objectives as outlined in Section 12.

Through the data evaluation and reporting process of the RI, a few items were identified which may warrant additional work prior to implementation of a final cleanup remedy at the Site. These items are discussed individually below.

13.1 Background Metals in Groundwater Quality

Background concentrations of metals in groundwater quality was not evaluated as part of the RI. It is proposed that additional groundwater samples be collected from monitoring well MW-29, located upgradient of the former railyard activities. These samples should be analyzed for both for total and dissolved metals. The sampling should encompass both high groundwater (winter) and low groundwater (summer) conditions to evaluate potential seasonal fluctuations. These data are needed to further assess whether or not all of the metals identified as being above cleanup levels in Section 12.1 are indeed Site-related. The existing data are not sufficient to support the design or evaluation of active measures to control or otherwise limit concentrations of metals in groundwater.

13.2 Western Extent of TPH

Work conducted during installation of the interim measures revealed the presence of petroleum impacted soils further west along West River Drive than had been anticipated. Plans for any additional remedial measures within this area will include means to confirm the westernmost extent of the impacted soil and groundwater. Remedial plans can be developed with sufficient flexibility to account for this data gap.

13.3 Toxicological Data for TPH and Lead

Toxicological data are currently unavailable for TPH and lead. Therefore, MTCA cleanup levels based on protection of human health using Method B or Method C cannot be developed at this time. It is our understanding, however, that Ecology is in the process of evaluating TPH cleanup levels and the risk associated with TPH. If this process results in toxicological data or methods for calculating risk-based TPH cleanup levels before implementation of a final remedy at the Site, the TPH cleanup levels presented herein would be revised accordingly. Similarly, EPA is reviewing the toxicological data for lead and may develop data that could be used to calculate a lead cleanup level under MTCA Method B or C.

13.4 Method Detection Limits for SVOC

A few soil and sediment samples had high detection limits for SVOC. This means that low level SVOC concentrations cannot be completely ruled out at the Site - in fact, the analysis of ecological risks was conducted using a hypothetical PAH distribution. The soil samples and one of the sediment samples with high detection limits were also analyzed for TPH and had no or low levels of TPH. Because both SVOC and TPH analysis can detect the presence of diesel and Bunker C fuel oils, it is believed that the absence of some low level SVOC data does not adversely impact the overall Site characterization. However, further analysis of sediment PAH may be warranted with the close laboratory coordination to ensure that the lowest achievable detection limits are reported.

13.5 Sources of Off-site Metals

The maximum reported concentrations of beryllium, cadmium and mercury were reported in sample HA-2-1; this sample is not on BN property and the source of these metals is unknown. Elevated lead was reported in a HA-2 sample and in a sample from B-11, also located off BN property . The lead source is also unknown. Ecology has been notified and is expected to work with the property owners of these areas.

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FIGURES

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Figure 1-2 Site Location Map

Figure 1-3 Historical Facilities Map

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Figure 5-14 PCB Concentrations in Surface Soil Samples (µg/kg)

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Figure 6-6 November 1993 Total Petroleum Hydrocarbons Concentrations in Groundwater (mg/L)

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Figure 6-12 Areas of Historic LNAPL Occurrence

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Figure 9-1 Trench Location Map

Figure 11-1 Data Evaluation Process

Figure 11-2 Conceptual Site Model

TABLES

QUALIFIERS

B	—	Indicates compound was found in daily calibration blank.
J	—	Indicates compound was detected less than the MDL (Method Detection Limit) or result was estimated.
U	—	Indicates compound was not detected.
NA	—	Not Analyzed

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