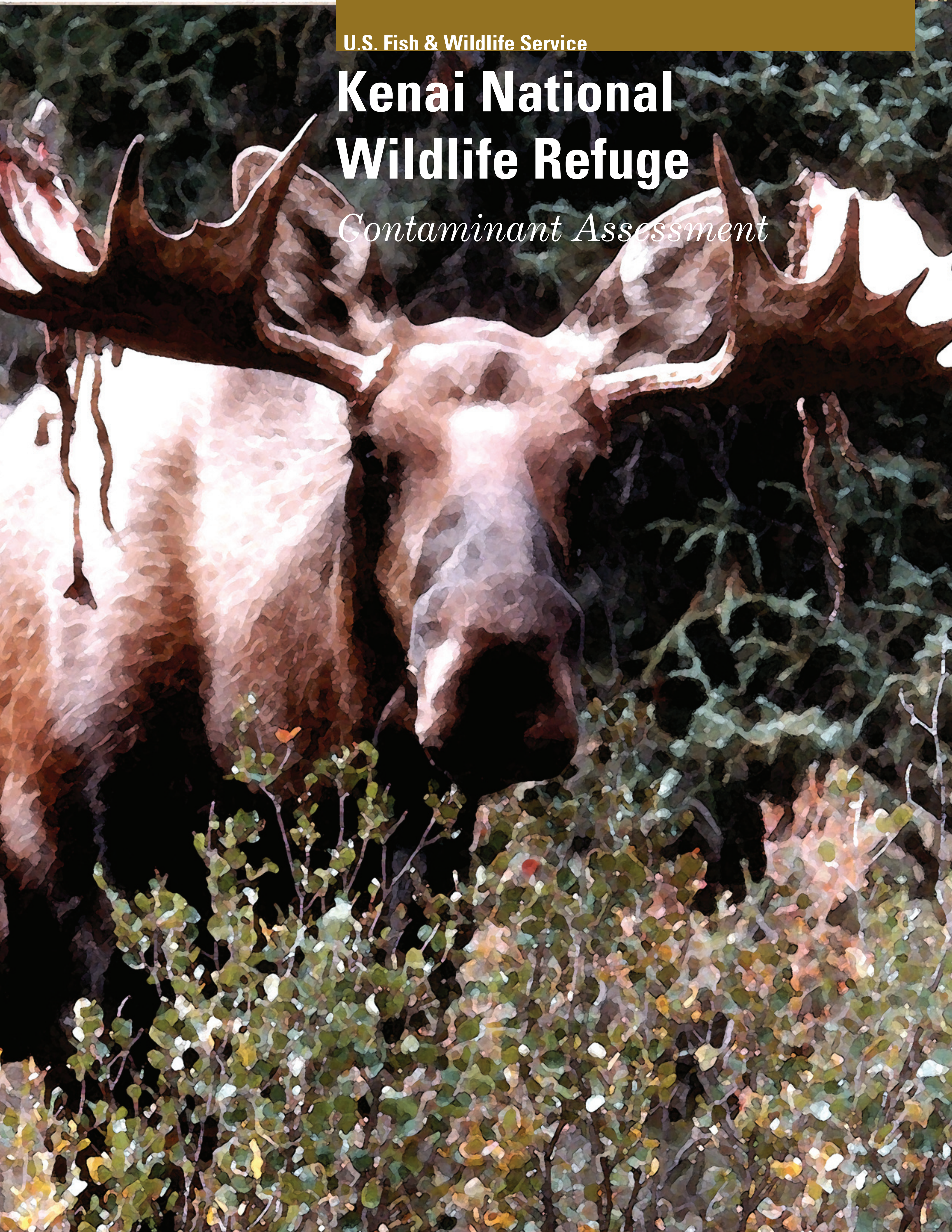
U.S. Fish & Wildlife Service

Kenai National Wildlife Refuge

Contaminant Assessment



Kenai National Wildlife Refuge
Contaminant Assessment

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Preface

Acknowledgements
Several people from a variety of agencies have contributed to this assessment. Their continual advice and support were essential for the completion of this project. I extend a special thanks to the personnel at the Kenai National Wildlife Refuge, especially Edward Berg, Vicki Davis, Jim Frates, Richard Johnston and Sue Schulmeister. Additionally, I would like to acknowledge Philip Johnson for providing invaluable input throughout the development of this document. Other people I would like to thank include the following: Christine Bailey, Jim Baker, Catherine Berg, Jill Birchell, Joel Bolduc, Mike Boylan, John Brewer, Bob Chivvis, John Clark, Debbie Corbett, Jim Coyle, Gregory Drzewiecki, Dave Johnson, Tim Kern, David Litchfield, Wendy Mahan, Diane Mann-Klager, Brian McMillen, Andrea Medeiros, Mark Meyer, Gary Moore, Judd Peterson, Bill Petrik, Dave Johnson, Stephanie Johnson, Ann Rappoport, Jordan Stout, Rich Sundet, Bruce Talbot, Nancy Tileston, Leslie Torrence, Gary Titus, Kim Trust, Larry Vanderlinden, Bill Walker, David Watsjold, Laura Whitehouse, Earle Williams, Blair Wonzell and Chuck Young.

Author's Notes

■Numerous sources were reviewed to create this document. Some of these sources include the following: Kenai National Wildlife Refuge (KNWR) Annual Narratives, contaminants files at Western Alaska Ecological Services (WAES) and Regional Ecological Services offices, consulting firm documents, internal U.S. Fish and Wildlife Service (USFWS) documents and various internet sources. Also a refuge visit was conducted from October 4, 1999 to October 8, 1999.

■Some parts of this document have been duplicated in their entirety from other USFWS sources as needed. Special care has been taken to cite these sources when large portions of them have been incorporated into this document. Some of these sources include the KNWR Annual Narratives (various authors) and A Summary of Reported Hydrocarbon Spills for Swanson River and Beaver Creek Operating Units 1956 to February 1999 by James E. Frates.

■All existing refuge narratives were extensively reviewed from a contaminants standpoint. The years reviewed were 1948-1995. The narratives from 1971, 1973, 1976 and 1977 could not be located and hence were not reviewed for this document. In 1964, the narrative reports switched from quarterly reports to annual reports. The narratives from 1996-1999 had yet to be completed upon compiling this document.

■Even though the refuge was called the Kenai National Moose Range until the passage of the Alaska National Interest Lands Conservation Act (ANILCA) on December 2, 1980, throughout this document it will be referred to it as the Kenai National Wildlife Refuge (KNWR).

Executive Summary

Although many people envision our National Wildlife Refuges as pristine havens for wildlife, many refuges also have contaminant issues. One aspect of maintaining environmental health for our refuges is to assess contaminant threats to refuge lands and resources. The U.S. Fish and Wildlife Service (USFWS) utilizes the contaminant assessment process (CAP) to document existing and potential contamination issues affecting refuges by assessing several factors including known/suspected contaminant sources, contaminated areas, contaminant transport pathways and areas vulnerable to spills/contamination. By utilizing the CAP, a comprehensive inventory of known and potential contamination threats is developed. Assessment results allow USFWS personnel to understand contaminant issues affecting trust resources, prioritize necessary sampling and/or cleanup actions, develop proposals for future investigations, initiate pollution prevention activities and incorporate contaminant issues into refuge Comprehensive Conservation Plans.

In 1999, the contaminant assessment process was initiated for the 16 National Wildlife Refuges in Alaska. Although many people think of Alaska as an untouched wilderness-the last frontier, Alaska is not immune to contaminant problems. In fact, its remoteness has contributed to its contaminant burden. Past and current uses of Alaska's lands have included a variety of activities including oil exploration and drilling, mining, military activities and even nuclear weapons testing. Many times after operations ceased, sites were abandoned with little or no thought as to what was left behind. Because costs to transport wastes and debris from remote sites are considerable, entire facilities were commonly left intact or minimally cleaned. At other sites, hazardous materials were spilled with little or no subsequent cleanup. In many areas in Alaska, abandoned 55 gallon drums dot the landscape. These abandoned drums rust through with time, releasing their contents (if any) to the surrounding environment.

National Wildlife Refuges in Alaska are not impervious to contaminant threats, and many of them have colorful contaminant histories. This contaminant assessment report documents known and suspected contaminant threats to one such refuge, the Kenai National Wildlife Refuge.

Prior to and since its establishment, the KNWR has experienced a variety of activities which have introduced contaminants into the environment. This report documents numerous potential contamination sources and issues for the refuge including the following: oil and gas development, pesticide use, Formerly Used Defense Sites (FUDS), development near the refuge boundaries, mining, waste disposal, recreational uses, fires and fire retardants, inholders, aircraft accidents, biotic sources and physical transport of contaminants.

While compiling this assessment data, it became apparent that the primary source of spills and contamination events for the KNWR are related to oil and gas development. Currently, the KNWR is the only refuge in Alaska where commercial oil/gas production is permitted. Two oil and gas fields are in operation on the refuge, the Swanson River Field (circa 1956) and Beaver Creek Field (circa 1967). Throughout the years, literally hundreds of spills have occurred at these two fields, including a $40 million polychlorinated biphenyl (PCB) cleanup at Swanson River Field. Many of these contamination events went unnoticed for several years to decades, and it is likely that other unknown sources of contamination may exist at these fields.

Areas of concern, future sampling needs and potentially contaminated areas have been identified in this report. Because many contaminant issues went undetected for extended periods of time at Swanson River Field and Beaver Creek Field, a well-supported contaminant assessment and monitoring program is recommended. The refuge also could greatly benefit from more baseline studies, which assess contaminant levels in soil, sediment, water and biota. A paucity of data exists for establishing contaminant baseline levels on the refuge. Baseline data would be helpful in assessing the impacts from potential contamination events on and near the refuge. These data also could be used to establish the contaminant contribution from off-refuge sources, including atmospheric and biotic transport mechanisms. Ideally, contaminant baseline studies would occur on all of the National Wildlife Refuges in Alaska, followed by periodic trend monitoring.

Several potentially contaminated areas exist on the KNWR. Some of these areas are documented contaminant sites where formal cleanup activities have occurred; however, it may be beneficial to conduct additional sampling at these areas to determine if residual contamination is an issue. Other potentially contaminated areas have not been examined for contaminants. The following areas/species are recommended for future inspection and/or sampling:

1) PCB excavation, incineration and disposal sites at Swanson River Field (page 12).

2) Locations where oil and gas development-related fires and explosions have occurred (pages 28-29).

3) Former locations of PCB-containing transformers at Swanson River Field (page 29).

4) Former locations of mercury manometers at Swanson River Field (pages 29-30).

5) Locations where pesticides such as 2,4-D and 2,4,5-T were used (page 32).

6) Former Army recreational camp at Skilak Lake (page 35).

7) Naptowne Radio Relay site (pages 35-36).

8) Surprise Creek mining location (pages 44-46).

9) Cooper Creek watershed and the Kenai River downstream from where mining occurred on Cooper Creek (page 47).

10) Anadromous, migratory, and resident species to determine baseline contaminant concentrations and determine if biotic transport of contaminants is a concern (page 59).

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Acronyms and Abbreviations

2,4-D	2,4-Dichlorophenoxyacetic Acid
2,4,5-T	2,4,5-Trichlorphenoxyacetic Acid
ADEC	Alaska Department of Environmental Conservation
ANCSA	Alaska Native Claims Settlement Act
ANILCA	Alaska National Interest Lands Conservation Act
AOGCC	Alaska Oil and Gas Conservation Commission
ARCO	ARCO Alaska, Inc.
bbl	Barrel
BCF	Beaver Creek Field
BLM	Bureau of Land Management
BRD	Biological Resources Division
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CAP	Contaminant Assessment Process
CAS	Chemical Abstract
CBC	Circulating Bed Combustor
CIRI	Cook Inlet Region, Incorporated
Cis-1,2-DCE	Cis-1,2-dichloroethene
CO	Carbon Monoxide
DCE	Dichloroethene
DDT	Dichlorodiphenyltrichloroethane
DRO	Diesel Range Organics
FUDS	Formerly Used Defense Sites
gal	Gallon
HC	Hydrocarbons
HCH	Hexachlorocyclohexane
KNWR	Kenai National Wildlife Refuge
kW	Kilowatt
LC50	Median Lethal Concentration
LNG	Liquefied Natural Gas
MCL	Maximum Contaminant Level
ND	Not Detected
NPS	National Park Service
NOx	Nitrogen Oxides

P&S	Pipe and Supply
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated dibenzo-p-dioxin
PCDF	Polychlorinated dibenzofuran
PCE	Tetrachloroethene
PCP	Pentachlorophenol
PERP	Prevention and Emergency Response Program
PM	Particulate Matter
ppb	Parts per Billion
ppm	Parts per Million
POP	Persistent Organic Pollutants
RCRA	Resource Conservation and Recovery Act
RM	River Mile
ROW	Right-of-Way
RV	Recreational Vehicle
SQBs	Sediment Quality Benchmarks
SRF	Swanson River Field
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin (Dioxin)
TCDF	2,3,6,7-Tetrachlorodibenzofuran
TCE	Trichloroethene
TPH	Total Petroleum Hydrocarbons
UIC	Underground Injection Control
UNOCAL	Union Oil Company of California
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
UST	Underground Storage Tank
VC	Vinyl Chloride
VOC	Volatile Organic Compound
WACS	White Alice Communication System
WAES	Western Alaska Ecological Service

Contaminant Assessment Process

The mission of the U.S. Fish and Wildlife Service is working with others to conserve, protect and enhance fish, wildlife, plants and their habitats for the continuing benefit of the American people.

The United States Fish and Wildlife Service (USFWS) is the only Federal Government agency whose primary mission is to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. A primary way that the USFWS fulfills this important mission is to manage our country's National Wildlife Refuges, which encompass over 93 million acres. The mission of the National Wildlife Refuge System (System) "is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife, and plant resources and their habitats within the United States for the benefit of present and future generations of Americans" [16 USC § 668dd(a)(2) (1998)]. It is the responsibility of the USFWS to "ensure that the biological integrity, diversity, and environmental health of the System are maintained for the benefit of the present and future generations of Americans" [16 USC § 668dd(a)(4)(B)].

"The mission of the National Wildlife Refuge System is to administer a national network of lands and waters for the conservation, management, and where appropriate, restoration of the fish, wildlife and plant resources and their habitats within the United States for the benefit of present and future generations of Americans."

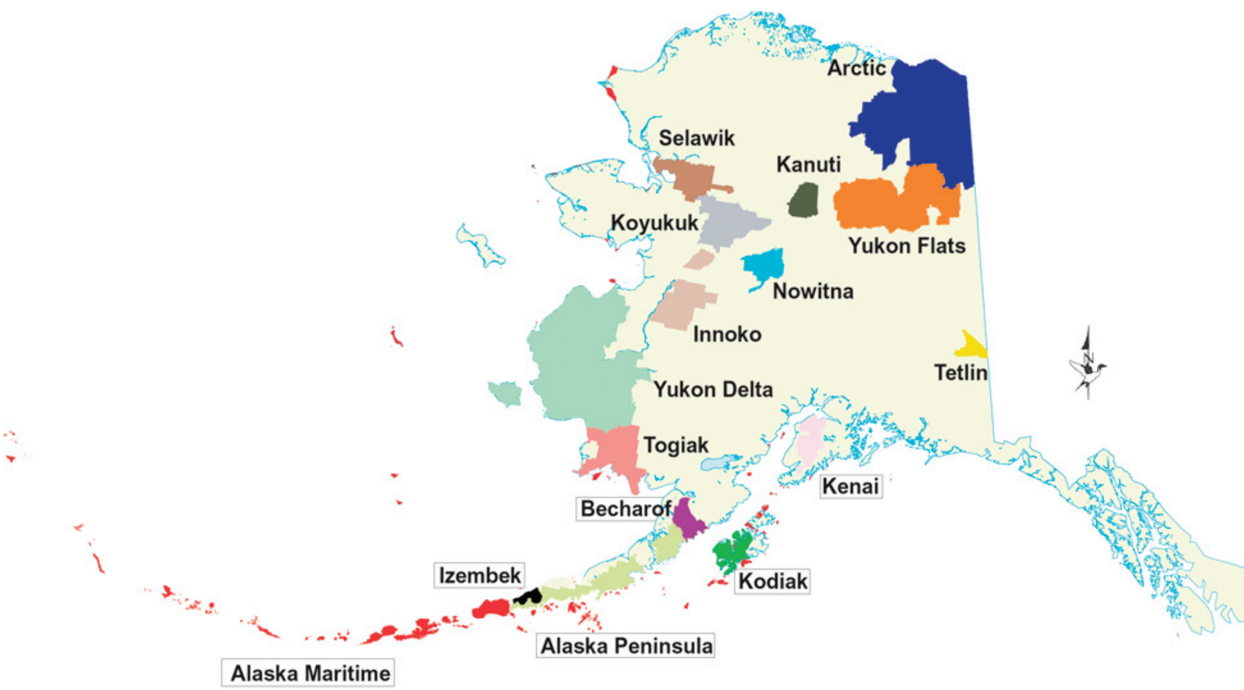
National Wildlife Refuge System Improvement Act of 1997

One aspect of maintaining environmental health for our National Wildlife Refuges is to assess contaminant threats to refuge lands and resources by utilizing the contaminant assessment process (CAP). Although people may envision wildlife refuges as pristine havens for wildlife, many refuges have contaminant issues. The contaminant assessment process was developed by the United States Geological Survey Biological Resources Division's (USGS/BRD) Biomonitoring of Environmental Status and Trends BEST) Program and the USFWS's Division of Environmental Contaminants (DEC). The USFWS utilizes the CAP to document existing and potential contamination issues affecting refuges by assessing several factors including known/suspected contaminant sources, known/suspected contaminated areas, contaminant transport pathways and areas vulnerable to spills/contamination. By utilizing the CAP, a comprehensive inventory of actual and potential contamination threats is developed and entered into CAP's national database. Assessment results allow USFWS personnel to understand contaminant issues affecting trust resources, prioritize necessary sampling and/or cleanup actions, develop proposals for future investigations, initiate pollution prevention activities and incorporate contaminant issues into refuge Comprehensive Conservation Plans.

In 1999, the contaminant assessment process was initiated to evaluate contaminant issues for the 16 National Wildlife Refuges in Alaska (Figure 1). Over 80% of the National Wildlife Refuge lands are in Alaska, totaling over 76 million acres. While the large size and remoteness of the refuges in Alaska present special challenges for utilizing and applying the CAP, valuable information about potential contaminant threats still can be gained by using this process.

Many people envision Alaska as pristine wilderness-the last frontier; however, Alaska is not immune to contaminant issues. In fact, its remoteness has contributed to its contaminant burden. Past and current uses of Alaska's lands have included a variety of activities including oil exploration and drilling, mining, military activities and even nuclear weapons testing. Many times after operations ceased, sites were abandoned with little or no thought as to what was left behind. Because costs to transport wastes and debris from remote sites are considerable, entire facilities were commonly left intact or minimally cleaned. At other sites, hazardous materials were spilled with little or no subsequent cleanup. In many areas in Alaska, abandoned 55 gallon drums (and other similar containers) dot the landscape. These abandoned drums and containers rust through with time, releasing their contents (if any) to the surrounding environment. Even the National Wildlife Refuges in Alaska are not impervious to contaminant threats, and many of them have colorful contaminant histories. This contaminant assessment report documents known and suspected contaminant threats to one such refuge, the Kenai National Wildlife Refuge.

Figure 1. The 16 National Wildlife Refuges in Alaska.



Graphics by USFWS.

Kenai National Wildlife Refuge

The first refuge in Alaska to receive a contaminant assessment was the Kenai National Wildlife Refuge (Figure 2). The results of the contaminant assessment are presented in this report. In addition to this report, contaminant assessment data were entered into CAP's national database.

Figure 2. Location of the Kenai National Wildlife Refuge on the Kenai Peninsula, Alaska.

Graphics by USFWS.

The following synopsis describing the KNWR is the Introduction contained in the most recent Kenai National Wildlife Refuge Annual Narratives:

> *The Kenai National Wildlife Refuge is located on the Kenai Peninsula in southcentral Alaska. The northern portion of the Refuge is just 15 air miles from the state's largest population center, the city of Anchorage. Despite its proximity, a scenic 112-mile drive through the Kenai Mountains is necessary to reach the nearest portion of the Refuge by road from Anchorage. Commercial commuter aircraft fly into the nearby cities of Kenai and Soldotna daily.*
>
> *Extending 115 miles from Turnagain Arm on the north to nearly the Gulf of Alaska on the south, the Refuge encompasses about one-third of the Kenai Peninsula. The western portions of the Kenai Mountains generally form the eastern Refuge boundary; a*

common boundary shared with our Chugach National Forest and Kenai Fjords National Park neighbors.

Since the establishment of the Refuge as the Kenai National Moose Range on December 16, 1941, under E.O. 8979, these lands have undergone at least two boundary changes and a name change.

The original Refuge included 2,058,000 acres and, among other mandates, authorized settlement, location, and other disposition under public land laws applicable to Alaska. At that time, the Refuge was bounded on the northwest, from Point Possession to the Kasilof River, by the waters of Cook Inlet. A six-mile-wide strip of land from Boulder Point to the Kasilof River and a six-mile strip of land, including portions of the Kenai River, were left open for development. Homesteads, grazing areas, road systems, and other developments occurred in these areas, and they were excluded from the Refuge during a 1964 boundary adjustment. Excluded at the same time were Cook Inlet coastal lands one to three miles inland and considerable portions of the Harding Ice Field, reducing the Refuge area to 1.73 million acres.

Passage of the Alaska National Interest Lands Conservation Act (ANILCA), commonly known as "The Alaska Lands Act," on

The Kenai National Wildlife Refuge was initially established as the Kenai National Moose Range in 1941. USFWS Photo by Michael F. Boylan.

December 2, 1980, redesignated the Kenai National Moose Range as the Kenai National Wildlife Refuge.

The Act also increased the Refuge acreage, adding approximately 150,000 acres at the southern tip of the Refuge and about 90,000 acres of former Forest Service lands to the extreme northeast portion of the Refuge near Chickaloon Flats. At the same time, passage of ANILCA withdrew 16,535 acres from the Refuge to satisfy the claims of the Salamatof Native Association under the Alaska Native Claims Settlement Act of 1971. The now 1.97 million acre Refuge was reestablished and its purposes redefined as follows: 1) conserve fish and wildlife populations and habitats in their natural diversity including, but not limited to, moose, bears, mountain goats, Dall sheep, wolves and other furbearers, salmonoids and other fish, waterfowl and other migratory and nonmigratory birds; 2) fulfill international treaty obligations of the United States with respect to fish and wildlife and their habitats; 3) to ensure, to the maximum extent practicable and in a manner consistent with the purposes set forth in paragraph (1), water quality and necessary water quantity within the refuge; 4) provide in a manner consistent with subparagraphs (1) and (2), opportunities for scientific research, interpretation, environmental education, and land management training; and 5) provide, in a manner compatible with these purposes, opportunities for fish and wildlife-oriented recreation. In addition to establishing a new name, new boundaries, and new purposes, ANILCA formally designated 1.35 million acres of the Refuge as wilderness.

The Refuge is divided into two main physiographic regions: a mountainous region and a forested lowland. Elevations on the Refuge range from sea level to more than 6,600 feet in the Kenai Mountains, with treeline at about 1,800 feet. Among the peaks of the Kenai Mountains lies the Harding Ice Field, which thrusts numerous glacial fingers out into the Refuge. The glaciers, mountains, lakes, alpine tundra, and foothills are extremely scenic.

Thirty-nine percent of the Refuge is forested. Swampy forests of black spruce alternate with peatbogs and grassy mires while white spruce forests dominate the drier areas and the foothills and mountains. White spruce stands are often intermixed with and include deciduous trees, such as white birch and aspen, especially in old burns and cut-over areas. Lowland shrub (alder and willow) covers nine percent of the Refuge. Mountain tundra covers about 11 percent. Of this class, about 87 percent is dwarf shrub and lichen tundra, and 13 percent is tall shrub (alder and willow) thickets usually associated with tundra. Water and associated wetlands cover 13 percent, and snow, ice, and glaciers cover the remainder of the Refuge.

The Kenai River, the largest river system on the peninsula, drains about 2,148 square miles (5,563 km2).

About 54 percent of the watershed is on the Refuge, 37 percent in the Chugach National Forest, and the remainder on private *lands. Ten major tributaries feed the Kenai River System: Beaver Creek, Slikok Creek, Soldotna Creek, Funny River, Moose River, Killey River, Skilak River, Russian River, Cooper Creek, and Juneau Creek. Other Refuge river and stream systems flowing westward into Cook Inlet include the Kasilof River (which drains Tustumena Lake), Deep Creek, and the Swanson, Fox, Ninilchik, and Chickaloon Rivers.*

There are thousands of lakes on the Kenai Peninsula, and most of them are on the Refuge. The largest are two glacial lakes, Tustumena Lake (74,000 acres or 31,000 ha) and Skilak Lake (25,000 acres or 10,000 ha). More than 4,500 smaller lakes dot the Refuge, mostly in the Moose, Swanson, and Chickaloon River drainages.

At least 199 species of amphibians, birds, and mammals use the wildlife habitats on the Refuge. None of these species are known to be threatened or endangered. Five species of salmon, a wide variety of furbearers, and significant populations of brown and black bear, sheep, goats, wolves, Bald Eagles, Trumpeter Swans, caribou, moose, and loons occur on the Refuge.

Boreal owl. USFWS Photo by Theodore N. Bailey.

Lynx. USFWS Photo by Theodore N. Bailey.

Sockeye salmon. USFWS Photo.

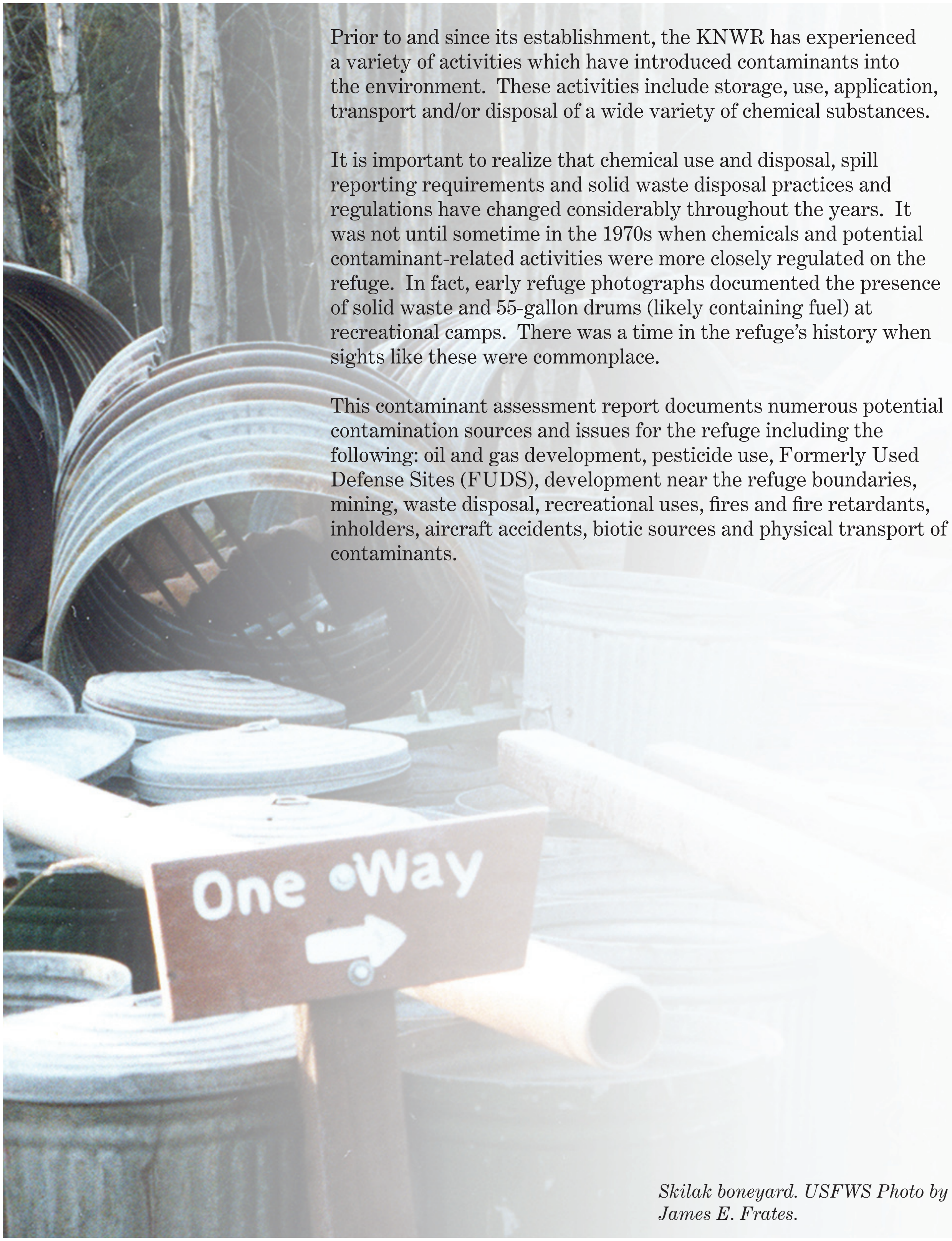
Caribou. USFWS Photo by James E. Frates.

Contaminant Sources and Issues

Prior to and since its establishment, the KNWR has experienced a variety of activities which have introduced contaminants into the environment. These activities include storage, use, application, transport and/or disposal of a wide variety of chemical substances.

It is important to realize that chemical use and disposal, spill reporting requirements and solid waste disposal practices and regulations have changed considerably throughout the years. It was not until sometime in the 1970s when chemicals and potential contaminant-related activities were more closely regulated on the refuge. In fact, early refuge photographs documented the presence of solid waste and 55-gallon drums (likely containing fuel) at recreational camps. There was a time in the refuge's history when sights like these were commonplace.

This contaminant assessment report documents numerous potential contamination sources and issues for the refuge including the following: oil and gas development, pesticide use, Formerly Used Defense Sites (FUDS), development near the refuge boundaries, mining, waste disposal, recreational uses, fires and fire retardants, inholders, aircraft accidents, biotic sources and physical transport of contaminants.



Skilak boneyard. USFWS Photo by James E. Frates.

Oil and Gas Development

The oil and gas fields in operation on the refuge may pose the largest contamination threats to the refuge.

The oil and gas fields in operation on the refuge may pose the largest contamination threats to the refuge. Currently, the KNWR is the only refuge in Alaska where commercial oil/gas production is permitted. The USFWS regulates surface operations, and the Bureau of Land Management (BLM) regulates subsurface operations. This section will discuss the two main oil/gas fields on the refuge, Swanson River Field (SRF) and Beaver Creek Field (BCF), major spills associated with these fields and additional potential contamination events/sources associated with oil/gas development. For information about general petroleum toxicity, please see Appendix A.

Swanson River Field

On July 19, 1957, Alaska's first significant oil reserves were struck at SRF in the heart of KNWR. Swanson River Field was Alaska's first oil/gas field, and its oil production was a major catalyst for Alaska's statehood. Since discovery in 1957, considerable oil exploration and development have occurred on the KNWR, resulting in numerous oil and hazardous material spills. The following companies have been the operators of SRF: Chevron USA, Inc. from 1957 - September 30, 1986; ARCO Alaska, Inc. from October 1, 1986 - December 15, 1992; Union Oil Company of California (Unocal) from December 16, 1992 to present. The SRF is located approximately twelve miles north of Sterling, Alaska. A detailed description of SRF is summarized by James E. Frates (1999a), Operations Specialist for Kenai National Wildlife Refuge:

> *The Swanson River Field occupies approximately 12 square miles and includes the following: 30 miles of road, 60 well pads, seismic lines, 177 acres of building and storage areas, 5 residences, office and maintenance shop building, large compressor plant for gas injection, oil pumping station, 35 acres of gravel and sand pits, a solid waste disposal site, a pipeline complex from each well to 7 tank settings, 7 flaring stacks, a 6 inch crude and 12 inch gas pipeline from the field to Nikiski, two steel girder bridges over the Swanson River, two power lines crossing the river, a power line complex throughout the field, in addition to the main feeder line coming from Nikiski within the underground pipeline corridor.*

Jim Frates, Kenai National Wildlife Refuge Operations Specialist, at the Swanson River Field discovery well. USFWS Photo by Tiffany A. S. Parson.

This section details some of the major spills and contamination events that have been reported at Swanson River Field from 1956 to April 2000. Most of the spill information from 1957 to February 1999 was taken from a report by Frates (1999b). An unabridged version of this report may be found in Appendix B. It is important to note that the number of *reported* spills may differ from the number of *actual* spills, especially during the early years of oil/gas production. The refuge Annual Narratives report several instances where fires and spills apparently went unreported and were discovered by refuge staff at later dates. While a complete listing and discussion of all known spill events is beyond the scope of this assessment, a number of significant spills and contamination events are summarized in this section.

Major Spills and Contamination Events Reported at Swanson River Field

Reported Spills at Swanson River Field from 1957 to February 1999.

292 Reported Spills (7 spills/year average)

--35 gallons (gal) anti-freeze
--65 gal methanol
--85 gal hydraulic fluid
--100 gal solvents
--452 gallons diesel fuel
--2,213 gal triethylene glycol
--24,169 gal crude oil
--238,749 gal produced water
--unknown quantity of xylene released at Pipe and Supply Yard

Source: Frates (1999b)

Flowline Break - 1961

In early 1961, a line break at well site 32-8 caused oil spray to reach the Swanson River (over 2,000 feet from the well head). This discovery, that oil reached the Swanson River, did not happen until the spring thaw occurred.

Diesel Fuel and Engine Oil Leak - 1963

This information was taken from the January-April 1963 Annual Narrative:

> *In spite of additional conditions imposed on the Unit Operator prior to completing construction of temporary access road and location…and continued checks during drilling operations, diesel fuel and engine oil escaped the sumps due to dike breaks and polluted the surrounding country side. Complete cleanup was demanded, but before equipment became available incessant winter rain flooded the frozen muskeg and carried off the pollutants depositing them elsewhere.*
> (page 29)

Contamination from Drilling Operations - 1968

This information was taken from the 1968 Annual Narrative:

> *During drilling operations at the Swanson Lakes Well #1, an adjacent pothole to the drilling pad was contaminated, as was the surrounding vegetative cover. Consequently, during an August inspection of Texaco's cleanup progress the refuge staff observed this pothole in a very contaminated condition. Considerable damage to surrounding timber and vegetation had resulted from the oil and caustic soda pumped into the pothole.*
> (page 41)

Flowline Break - April 18, 1969

A 4" flowline serving well 4-34 separated at the "Dressler Coupling," approximately 40 feet east of the Swanson River. The line was originally a low-pressure line; however, it was converted to high-pressure without reinspection of the coupling. The coupling failed, allowing crude to spray out and into the Swanson River. Because the line was shut in almost immediately, the quantity spilled was minimal (no estimate given). Three burlap absorbent booms were placed in the Swanson River (ice-packed at the time) between the spill site and the south bridge, and a vacuum truck was used to extract free product. By using the booms and vacuum truck, crude was prevented from flowing past the south bridge.

Compressor Plant Explosion - January 27, 1972

A 1984 nationwide environmental contaminant survey on refuges where oil and gas operations existed revealed the presence of polychlorinated biphenyl (PCB) compounds at SRF in soil samples within the road right-of-ways (ROWs). For general information about PCB toxicity, please see Appendix C. Preliminary sampling at SRF preformed on July 22, 1984 revealed PCB concentrations of 30 parts per million (ppm) in a road sample collected near the administration building and 10 ppm in a sample from the SCU 14-3 sump.

In 1983 and 1984, Chevron (then unit operator) had been permitted by the Alaska Department of Environmental Conservation (ADEC) and the U.S. Fish and Wildlife Service to spread oily gravel stored in the 14-3 gravel pit (SCU 44-4) on interior field roads for fugitive dust control. The source of the contamination was eventually traced to the storage site at the 14-3 gravel pit. Chevron used this pit since the 1970s to store crude-laced gravel excavated during spill cleanup operations. The source of the PCBs was further traced to gravel extracted (and stockpiled at the 14-3 site) from and around the compressor plant explosion that occurred in 1972 .

The source of PCBs (Aroclor 1248) was found to be a thermal inhibiting liquid used in the multi-stage compressor engines; it was released in and around the compressor plant during the explosion. From 1962 to 1972, Aroclor 1248 was used in the process heat transfer system at the compressor plant. Following the compressor plant explosion in 1972, Therminol FR-1 (Aroclor 1242) was used. By 1977, Therminol FR-1 was replaced with Therminol 66, which did not contain PCBs. However, testing in 1982, revealed residual contamination of 381 ppm Aroclor 1242 in the Therminol 66. Upon this realization, the fluids were drained, and the system was

Compressor plant explosion at Swanson River Field on January 26, 1972. The compressor facility (still in operation) provided high-pressure gas for reinjection into oil producing formations, forcing crude to the surface. USFWS Photo by Richard A. Richey.

The PCB cleanup at Swanson River Field is estimated to have cost over $40 million.

flushed. As of 1988, less than one ppm PCBs remained in the system (Metsker, 1988).

In 1985, Chevron agreed to proceed with cleanup operations under an "Order by Consent," with the USFWS, ADEC and BLM. The Consent Order triggered, what was at that time, the largest PCB remediation effort ever undertaken on Federal lands (Crab Orchard NWR now has that dubious honor).

Chevron's consultant, Ecology and Environment, Inc., conducted site assessment and characterization studies in all areas within the field where known contamination existed. These sites were excavated, and contaminated material was hauled to a designated processing site at the 14-3 gravel pit.

In 1986, ARCO Alaska, Inc. (ARCO) took over as unit operator of the Swanson River Field. They assumed all cleanup liability previously imposed on Chevron under the Consent Order. On August 10, 1987 during PCB excavation activities around the foundations of the therminol heater building and compressor plant buildings A and B, high PCB concentrations and 2,3,6,7-tetrachlorodibenzofuran (TCDF) were discovered. PCB concentrations ranged from 8,000 ppm to 220,000 ppm. It is speculated that TCDF contamination resulted from incomplete combustion of PCBs from a fire at the therminol heater building on August 30, 1968.

PCB contaminated soils were excavated from several miles of road within Swanson River Field.

Site assessment and characterization continued as well as excavation of all sites where soil sampling indicated the presence of PCBs in excess of 12 ppm (Figure 3). ARCO entered into a contract with Ogden Environmental Services for the installation and operation of a natural gas-fired circulating bed combustor (CBC) to incinerate all contaminated soil that had been excavated throughout the field. Following EPA licensing and permit authorization, the CBC began operations in 1987. The CBC continued operations until the summer of 1992, following the incineration of over 107,000 tons of

Circulating bed combustor. USFWS Photo by Robert A. Richey.

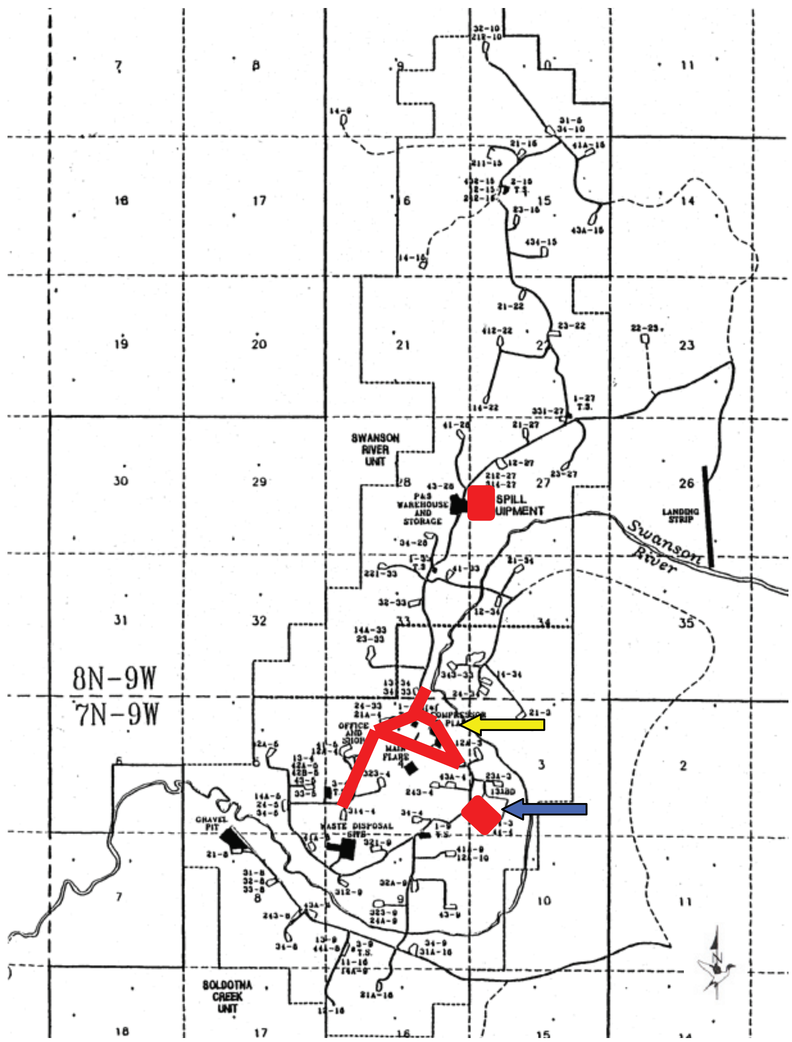
The circulating bed combustor operated from 1987 to 1992 and incinerated over 107,000 tons of PCB contaminated soils.

contaminated soils. The only known remaining PCB contamination is beneath the rebuilt compressor plant. Under terms of the Consent Order, remediation of this area has been deferred until the compressor plant is demobilized. Water samples are taken from perimeter monitoring wells biannually and analyzed for PCB compounds; all results to date have been negative, suggesting that this contamination has not migrated off-site.

All incinerated soils from the CBC were spread just to the west of the 14-3 site. In 1992, the area was covered with a layer of topsoil and seeded with a mixture of northern variety grasses.

Numerous technical reports were generated during this extensive project, and a listing of these reports can be found in the Bibliography and Literature Cited for this assessment.

Figure 3. Schematic of PCB Excavation Areas at Swanson River Field.



Areas in red approximate major PCB excavation areas; the yellow arrow (top) is pointing toward the compressor plant; the blue arrow (bottom) is pointing at the 14-3/44-4 site, where PCB contaminated soil was stockpiled from the compressor plant explosion and where incinerated soils were processed and spread.

Gas Blow Out - 1986

On December 12, 1986, field personnel noticed surface gas venting in several locations near well 44-8 (southwest of south bridge) in the extreme southern part of the field. Apparently the tubular string from one of several wells on the 44-8 pad had perforated, allowing gas to escape upward through the formation and eventually venting at the surface in several adjoining locations, including the south bank of the Swanson River nearly a 1/4 mile to the north of the 44-8 pad. A "Hot Shot" crew from Texas was dispatched to Swanson River in an attempt to locate the source of the leak and bring it under control. The culprit well SCU 11-16, was finally "killed" on December 25, 1986. While some crude oil pooled to the surface on pad 44-8 during the two weeks of venting, environmental damage was minimal.

As the media reported events of the blow out, several people in the Sterling area claimed their wells had either gone dry or were contaminated. Further investigations by ADEC revealed no relationship between the Sterling wells and the blow out at Swanson River Field.

In 1988, during investigations associated with the PCB remediation project, xylene contamination was discovered in soils and groundwater at the Pipe and Supply Yard within Swanson River Field.

Xylene Release at Pipe and Supply Yard - 1988

In 1988, during investigations associated with the PCB remediation project, volatile organic compound (VOC) contamination was discovered in soils and groundwater at a supplies and materials storage site, known as the Pipe and Supply (P&S) Yard (ADEC spill number is 1988230118301).

Site characterization activities were initiated to determine the specific compounds present and the source and distribution of these compounds in the environment. VOC contamination consisted primarily of ethylbenzene, toluene, xylene and traces of benzene (collectively, BTEX). The source of contamination was apparently an aboveground tank farm within the P&S Yard, where several thousand gallons of xylene had been stored at one time. Xylene is used to inhibit the build up of asphalt in the higher temperature zones in well casings. The release of xylene was never documented, and it was never determined if the xylene release occurred as a single major catastrophic event or as a recurring leak over an extended period of time. At any rate, the release was never reported, and the quantity spilled is unknown. For general information about xylene toxicity, please see Appendix D.

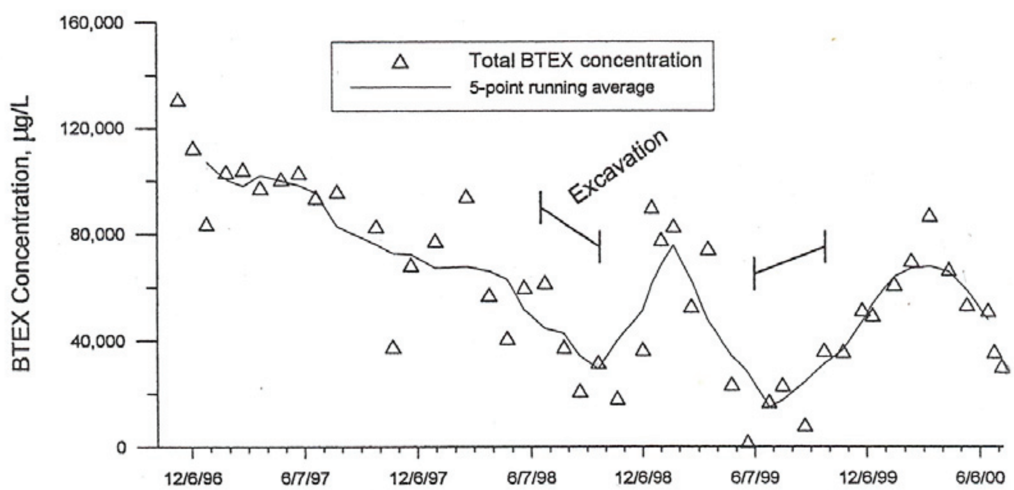
Unit operator, ARCO, contracted with the consulting firm, Ecology and Environment, Inc., to complete a BTEX Risk Assessment and develop a Remedial Action Plan. Cleanup levels were established for both groundwater and soils (0.2 ppm and 1.5 ppm, respectively, for xylene) and presented for agency review and comment. The established cleanup levels were later incorporated as Amendment 5 of the Consent Order, thus directing ARCO to proceed with their remediation work.

From 1989-1992, ARCO attempted to reduce influent levels of BTEX (primarily xylene) present in excess of 100 ppm by pumping water from an intercept trench at the lower end of the affected area back through a 6" line into an air-sparging system. High iron and magnesium in the groundwater created constant maintenance problems with the air-sparging system. This, combined with the exceedingly high levels of xylene present in the groundwater, prevented any significant drop in contaminant levels. It became apparent that significant progress toward remediation only would occur by locating, excavating and treating soils saturated with xylene. The groundwater monitoring results from December 1996 to July 2000 are presented in Figure 4. The BTEX levels appear to fluctuate seasonally.

When Unocal took over the field in 1992, they began working on a new remediation plan, which included further sampling to delineate "hot spots" and an aggressive excavation plan whereby soils would be placed into "biopiles" and infused with air via a positive-flow circulating system. The first excavation of soils took place in 1995 and continued through 1998. The air-circulating system was abandoned (due to soil compacting in the biopiles) in favor of "land-farming" during the summer of 1998, where all excavated materials were spread over the area and frequently tilled using mechanical two-wing discs.

Because of the expected long-term nature of the remediation effort at the P&S Yard, Unocal is developing a plan similar to an approach used by Marathon Oil Company (Marathon) at their Poppy Lane site near the Kenai Gas Field (the Poppy Lane site is not on the KNWR). The plan is based on the concept of phytoremediation in an engineered wetland setting. Phytoremediation takes advantage of the nutrient utilization process used by plants, where water and nutrients are taken up through the roots, and water is transpired through the leaves. This same process is used as a transformation system to metabolize organic compounds, such as xylene. Additionally, plants stimulate soil microbes, which ultimately results in enhanced bioremediation. Bioremediation is a process where

Figure 4. Influent Monitoring Results for the Groundwater Treatment System from December 1996 to July 2000.



Incomplete engineered wetland at the Pipe and Supply Yard at Swanson River Field. USFWS Photo by Tiffany A. S. Parson.

microbes breakdown organic contaminants. During summer 2000, wetland construction was completed.

A number of technical reports related to the xylene remediation project are available, including monthly reports on groundwater sampling (see Bibliography and Literature Cited).

Flare Stacks and Tank Setting Contamination - 1989

Hydrocarbon contamination discovered around flare stacks resulted in an Environmental Site Investigation for all seven tank settings and their associated gas flaring stacks. A number of soil borings were done at each site in order to determine the extent and configuration of hydrocarbon contamination. A total of 21 monitoring wells were installed around the periphery of the seven sites to establish information on possible groundwater contamination.

The following sites at Swanson River Field have elevated petroleum hydrocarbon concentrations in soil (total petroleum hydrocarbon (TPH) concentrations above 100 ppm or BTEX presence): electric shop, 243-4 mud disposal well pad, 1-4, 1-9, 1-27, 1-33, 2-15, 3-4 and 3-9 tank settings and their corresponding flare stacks and the main flare stack. Additionally, groundwater contamination (total petroleum hydrocarbon (TPH) concentrations above 5 ppm or BTEX presence) exists at the following: electric shop, 1-4, 1-9, 1-27, 1-33, 2-15, 3-4 and 3-9 tank settings and 1-4, 1-9, 1-33, 2-15, 3-4 and 3-9 flare stacks.

A site assessment of each flare stack delineated the extent of crude contamination. USFWS Photo by Robert A. Richey.

Unocal has temporarily halted their efforts on the tank settings and flare stacks pending resolution of the P&S Yard remediation project. The sites appear stable, and contamination does not appear to be migrating beyond known areas. Unocal is considering doing a risk assessment for all seven sites.

Technical reports are available (see Bibliography and Literature Cited).

Flowline Leak - 1991

On November 25, 1991, crude oil was observed just off the road right-of-way near well pad 21-22. A small pinhole leak was discovered in a 4” flowline (internal corrosion) resulting in the release of an estimated 630 gallons of crude and approximately 5,000 gallons of produced water. The contaminated area was approximately 30’ by 30’ in a predominately alder stand. A vacuum truck removed most of the crude within hours of the discovery, and the remaining crude was picked up by a track hoe and taken to the solid waste site on SRF. Topsoil was spread over the area, and the area was left to grow back naturally.

Flowline Break - 1994

On February 23, 1994, a 6” flowline failed due to internal corrosion near the 3-9 tank setting 1/4 mile south of the Swanson River and west of the south bridge. An estimated 2,000 gallons of crude were released mostly beneath the ground surface and within the pipeline corridor. Most of the crude was captured in the soil; approximately 200 cubic yards of material were excavated and taken to the solid waste site. Clean fill was transported to the site and dumped in the previously excavated area.

Flowline Break - 1995

On May 17, 1995, crude oil was discovered on the ground during a routine inspection on a 6” underground flowline from the 3-9 tank setting, approximately 100’ north of where the line crosses the Swanson River. Crude loss was estimated at approximately 400 gallons, most of which was retrieved by a vacuum truck. A silt fence was placed immediately between the break and the Swanson River, thus preventing any further migration of oil. Because the spill event occurred in a wet boggy area near the river, the line was purged of all hydrocarbons and left in place without further excavation to prevent causing further disturbance to the wetland. The line was replaced by an aboveground line. While corrosion was suspected as the cause, the line was never excavated because of the potential for further disturbance/damage.

Flowline Break - 1999

On January 7, 1999, a flowline break was discovered when a recreational snowmobiler noticed crude pooling within the pipeline/power line right-of-way just to the west of the 1-27 tank setting (ADEC spill number is 99239900601). Final tally of product loss was placed at 228,648 gallons; approximately 95% (217,224 gallons) was produced water and 5% (11,424 gallons) was crude oil.

Cleanup operations continued from January 8, 1999 to January 28, 1999. The majority of the crude was either extracted by vacuum trucks or excavated with a tracked hoe. Four carbon filtration dams were installed downstream from the site and a small earthen dam was constructed for skimming free product. The site was monitored daily and product vacuumed as necessary or as weather permitted. A site rehabilitation plan was developed. Hydroseeding of the site was completed by early July 1999 and revegetation is progressing.

Underground Pipeline Leak - 1999

On November 21, 1999, there was a leak in a 6" underground fiberglass pipeline used for transporting produced water to the wastewater disposal facility at tank setting 1-33. The spill occurred near the tank setting 1-4 wastewater building approximately ¼ mile from the Swanson River (ADEC spill number is 99239932501).

The spill was estimated to contain 8,600 gallons of produced water with less than one gallon of oil (ADEC, Prevention and Emergency Response Program, http://www.state.ak.us/local/akpages/ENV.CONSERV/dsparperp/unocal/status_03.htm). The produced water flowed through a culvert to an interception basin across the road. Approximately 7,000 gallons of produced water were recovered from the interception basin using a vacuum truck. The remainder of the produced water escaped the basin and flowed toward the Swanson River. Based on visual observations, the spill impact area appeared to extend to within 50' to 100' of Swanson River. Soil samples did not exceed ADEC's soil cleanup levels except for two samples closest to the spill, which exceeded the benzene cleanup levels. These locations will be resampled in the spring of 2000.

The high salt content in produced water can stress vegetation, as seen by the red leaves of this alder. USFWS Photo by James E. Frates.

Beaver Creek Field

The development of BCF (located approximately eight miles north of Soldotna, Alaska) began in 1967. Marathon Oil Company (Marathon) has been the only operator at this field. A list of the major operational units at BCF is provided by Frates (pers. comm.):

> *The Beaver Creek Field, encompassing about 8 square miles, was and continues to be primarily a gas producer. It includes the following: 1,000 barrel (bbl) crude storage tank, 5,000 bbl crude storage tank, (2) 300 bbl water injection storage tanks, gas dehydration unit, 4 "T" Packs used to heat gas and separate out water, gas lift compressor, 5 pads with 6 active wells (2 oil and 4 gas), 5 miles of 12" gas transport line, numerous in-field gas gathering lines (6" and 8") and oil gathering lines (4" and 6"), 4-cell solid waste site, office and maintenance facility (one building), 1 flare stack-gas pressure relief, 2 steel support bridges crossing Beaver Creek, 2 Caterpillar natural gas-fired electrical generators [230 kilowatt (kW) and 235 kW], (1) 2,000 gal aboveground diesel fuel storage tank.*

This section details some of the major spill/contamination events that have been reported at Beaver Creek Field from 1988 to April 2000 (spill records are complete for only these years). The spill information from 1988 to 1998 was taken from a report by Frates

Beaver Creek Field Well Number 4. USFWS Photo by Tiffany A. S. Parson.

(1999b) (Appendix A). It is important to note that the number of reported spills may differ from the number of actual spills.

Major Spills and Contamination Events Reported at Beaver Creek Field

Reported Spills at Beaver Creek Field from 1988 to 1998.

42 Reported Spills (4 spills/year average)

--2 gal percolite (corrosion inhibitor)
--3 gal hydraulic oil
--3 gal vehicle motor oil
--31 gal methanol
--163 gal triethylene glycol
--400 gal diesel fuel (single event)
--3,000 gal (plus) crude oil (2,800 galsingleevent)
--5,078 gal produced water

Source: Frates (1999b)

Discovery Well Blow Out - February 1967

While drilling the original discovery well in the Beaver Creek Unit, Marathon Oil Company experienced a catastrophic "blow out" when high pressure gas at the 9,300' level entered the well casing and escaped to the surface formation. The violent nature of the release sheared the well derrick from its substructure, buried equipment under 20' to 25' of formation debris and dispersed sand and gravel as far as 3/4 mile away from the rig. High pressure venting occurred for 11 days during which air traffic was diverted around the area. The well was eventually "killed" using "Hot Shot" crews from Red Adair's famous "Hell Fighters" group based in Texas. Marathon Oil abandoned the site after recovering the derrick and other supporting drilling equipment. Site restoration consisted of redistributing evicted formation material over the site, bringing top soil back over the area (saved from pad construction), fertilizing, and seeding to a mixture of native grasses and legumes.

In 1997 and 1998, a Marathon Oil employee, Charles Underwood, used this site for a Master's Thesis titled, *Surface Investigation at an Exploratory Drilling Site within the Kenai National Wildlife Refuge*. Underwood found incomplete revegetation at this site due to methane seepage. Additionally, water samples from three locations around the site revealed trace amounts of metals from drilling muds. This document is available in the Refuge library.

Tanker Rollover Spill - 1981

On November 6, 1981, a semi-tanker hauling crude slid on an icy access road while trying to avoid an oncoming truck. The semi-tanker rolled over on its side, off the road, and spilled approximately 64 bbl of crude over the ice/snow-covered peat. A vacuum truck recovered roughly 13 bbl, and recovering the remaining crude required the removal of the contaminated peat.

Tank Farm Spill - 1988

During the summer of 1988, crude oil was detected around an underground connecting flowline between a 5,000 and 1,000-bbl crude oil storage tank system near the Beaver Creek production office. Further investigation and site assessment revealed crude-saturated soils in the vicinity of the tanks. Immediately following this discovery, an attempt was made to drain the 1,000 bbl tank. To compound the problem, during the off-loading procedure a recycling hose separated, which resulted in an additional 2,800 gallons of crude oil being spilled.

Both tanks were relocated across the road from their original location, and the contaminated site was eventually excavated until sampling confirmed all traces of hydrocarbons were gone.

The excavated material (about 5,000 cubic yards) was transported to BCU Pad 7, where it was placed on an impervious liner and later

Excavation of contaminated soils resulting from the tank farm spill. USFWS Photo by Robert A. Richey.

incinerated. Periodic sampling of monitoring wells around the perimeter revealed no contamination of groundwater. The site was refilled with gravel and today is part of the industrial storage area at the Beaver Creek headquarters complex.

Technical reports are available (see Bibliography and Literature Cited).

Diesel Spill - 1990

In January of 1991, Marathon was in the process of converting their previously diesel-fired generator to natural gas. During removal of the 500-gallon aboveground diesel tank, which provided a fuel source for the generator, it was discovered that the primary fuel line from the tank to the generator (3' below the surface) had been leaking for some time. Marathon contracted with a consultant to conduct a site assessment and map the extent of the diesel plume. Because of USFWS concerns of hydrocarbons entering Beaver Creek, considerable effort was directed toward developing a better understanding of groundwater movement. Several monitoring wells were installed around the perimeter of the site and periodic groundwater samples were taken. A study conducted by Terrasat, Inc. concluded that continuous low permeability silt horizons appeared to be controlling contaminant migration above the groundwater table.

Over 1,000 cubic yards of diesel-contaminated material were excavated and transported to the Pad 7 site. The material was eventually incinerated and brought back to the site for fill.

Four wells are currently being monitored for hydrocarbon contamination, while two additional wells are designed as free product recovery wells. Free product has been recovered from the recovery wells, and the monitoring well samples suggest that contamination is not migrating from the site.

Technical reports are available (see Bibliography and Literature Cited).

Tanker Loading Spill - 1993

On January 7, 1993, while transferring crude oil from the 5,000 bbl storage facility to a tanker truck, an automatic shut-off valve failed to operate, causing approximately 120 gallons of crude to be released within the docking area. Most of the product was recovered with a vacuum truck and remaining product was mixed with sand and taken to the solid waste site.

Tanker Leak - 1993

On July 22, 1993, a 800 bbl capacity truck-tanker, owned by Jackson Construction Co., left the loading ramp with approximately 400 bbl of crude oil en route to the Tesoro Refinery. While approaching the bridge over the north fork of Beaver Creek, the driver noticed a dark mist coming from the vicinity of the tanker's forward bulkhead. When it became apparent that the mist was actually crude oil coming from a hairline crack in the forward bulkhead, the driver transferred crude to another compartment to keep the liquid below the crack. Total loss was estimated at less than 40 gallons. Personnel used shovels and buckets to retrieve contaminated gravel, which extended over a distance of approximately ¼ mile.

A 14-inch break in the forward bulkhead of this fully loaded tanker resulted in spilled crude oil along Marathon Road within the Beaver Creek Field. USFWS Photo by James E. Frates.

Summary: Oil and Gas Development

Some of the main concerns with oil and gas development include the following:

1) *unnoticed contamination events*
2) *aging flowlines and drain lines*
3) *spill potential along oil field roads*
4) *vulnerability of Swanson River and Beaver Creek to spill events*
5) *new oil and gas development*

Hundreds of spills have occurred at SRF and BCF, and more spills likely will occur in the future. Many of these contamination events went unnoticed for several years to decades. It is likely that other unknown sources of contamination may exist at SRF and/or BCF. Because SRF and BCF eventually will cease operations (SRF's oil production has declined significantly over the years), it is important to determine all possible contamination threats associated with these fields prior to field closeout.

One of the main concerns at SRF is the integrity of aging flowlines and drain lines. The SRF was established in 1957, and throughout the years many leaks/spills have occurred due to the corrosion of aging lines. Additionally as the field ages, the ratio of salt water to crude increases, and this higher salt water content expedites the corrosion of lines. The current unit operator, Unocal, is trying to remedy this situation by using chemical additives, inserting polyethylene liners into the existing flowlines and gathering lines and replacing older lines. Although the unit operators have made considerable efforts to repair/update/replace these lines and implement cathodic protection systems, the potential for leaks from aging lines still exists.

Severe corrosion in the 2-15 drain line prompted an extensive effort to determine the integrity characteristics of other long-buried lines within Swanson River Field. USFWS Photo by James E. Frates.

Another concern for both SRF and BCF is the transport of oil and other materials along the roads within and in/out of the fields. Currently at BCF, crude is transported once or twice daily to the Tesoro Refinery via tanker truck. Transporting oil and other materials within and in/out of SRF and BCF makes these roadways vulnerable to spill events, as demonstrated by the 1981 tanker rollover spill and the 1993 tanker leak at BCF (pages 19 and 21).

Additionally, Swanson River and Beaver Creek are vulnerable to spill events because both water bodies run through the oil/gas fields and are crossed by roadways and pipelines within the fields. It should be noted that the P&S Yard, which is currently contaminated with xylene, is up gradient of the Swanson River. However, groundwater from the site is undergoing remediation. There is a down gradient interception trench, and sampling indicates xylene has not reached the river.

Swanson River and Beaver Creek are important to many fish and wildlife species and serve as spawning areas for many fish species. Sockeye salmon (*Oncorhynchus nerka*), coho salmon (*Oncorhynchus kisutch*), dolly varden (*Salvelinus malma*) and rainbow trout (*Oncorhynchus mykiss*) spawn in Swanson River, and rainbow trout spawn in Beaver Creek.

It is anticipated that new oil/gas development will occur on the refuge. Currently, 172,229 acres of coal, oil and gas and an additional 14,154 acres of entire subsurface are conveyed to Cook Inlet Region, Incorporated (CIRI). Additionally, there are 13,252 acres of Federal

Cow moose and young feeding in Swanson River below the north bridge within Swanson River Field. USFWS Photo by James E. Frates.

lease land open to coal, oil and gas development. The total acreage open to coal, oil and gas development is constantly changing due to changes in land status. For the most recent land status, please contact the USFWS Division of Reality in Anchorage, Alaska at (907) 786-3490.

One promising area for oil and gas development is the Birch Hill Unit, located nine miles north of SRF. Another area is the West Fork Gas Field, which has less development potential. Development of these and other areas likely will be accompanied by some degree of controversy, particularly where operations encroach on undisturbed habitat. A current issue at the refuge is the proposed five-mile gas pipeline from BCF to Wolf Lake. Two major pipelines already cross refuge lands. These pipelines include the underground oil pipeline from SRF to Nikiski, which extends across eight miles of refuge lands, and the Enstar underground gas pipeline from BCF to Anchorage, which extends across 38.3 miles of refuge lands.

Additional Potential Contamination Events and Sources from Oil and Gas Development

Most of the major spill events for the oil and gas fields are described in the previous sections (also see Frates 1999b in Appendix A). However, during background investigations for this report, additional potential contamination events and sources were discovered in the KNWR Annual Narratives. It is likely that this is the first time the narratives have been reviewed comprehensively from a contaminants standpoint. Given the fact that the contaminant consequences of some of the explosions, spills, etc., on the oil/gas fields were not discovered until sometimes decades after the actual event occurred, it is crucial to document all known contamination events/potential events in this document.

The most poignant example of a contamination event that went undiscovered for several years was the SRF compressor plant explosion on January 26, 1972 (see pages 9-12). For fourteen years no one realized that this explosion released PCBs (Aroclor 1248). This unnoticed contamination event resulted in the spreading of PCB contaminated soils within SRF. The PCB cleanup lasted several years and is estimated to have cost over $40 million. It was only after a baseline survey of environmental contaminants on refuges with oil and gas development that this PCB contamination was discovered. This example highlights the importance of conducting baseline contaminants monitoring on refuges with potential contamination sources.

Over 1,000 soil samples were collected in association with the extensive PCB remediation efforts at Swanson River Field. USFWS Photo by Robert A. Richey.

The following sections contain information about potential contamination events and sources at the refuge related to oil/gas activities. The following topics are addressed: drilling muds and reserve pits, injection wells, explosions, fires, transformers, mercury manometers and seismic exploration.

> *Historically, numerous unlined reserve pits were utilized as part of oil and gas development on the Kenai National Wildlife Refuge to store drilling muds, fluids, cuttings and produced waters.*

Drilling Muds and Reserve Pits

The contamination potential of drilling muds has generated some controversy. At drill sites, typically unlined reserve pits served as storage for drilling muds, fluids, cuttings and produced waters. New regulations adopted by ADEC in 1996 require formal closure of inactive reserve pits (also known as monofills). According to Underwood (1998), "monofills are single-use waste disposal sites that are permitted with the intent of disposing of solid wastes which are not regulated under the Resource Conservation and Recovery Act (RCRA) as a hazardous waste" (page 1). According to the EPA's RCRA Orientation Manual (http://www.epa.gov/epaoswer/general/orientat/) under Subtitle C, "Certain wastes from the exploration and production of oil, gas, and geothermal energy are excluded from the definition of hazardous waste. These wastes include those that have been brought to the surface during oil and gas exploration and production operations, and other wastes that have come into contact with the oil and gas production stream (e.g., during removal of waters injected into the drill well to cool the drill bit)."

Numerous unlined reserve pits were utilized historically on KNWR, all of which were backfilled and today are difficult to locate. In 1998, ADEC inspected 68 drill sites at SRF, where reserve pits would have been located. The ADEC concluded that no apparent contamination was associated with these sites. The ADEC issued formal closure of these sites in May 1999. In 1999, the ADEC inspected 6 drills sites at BCF, where reserve pits would have been located. As of May 2000, ADEC had approved Marathon's reserve pit closure plan, although final site closure is still pending. ADEC estimates that an additional 6-8 reserve pits are located outside the current operating unit boundaries (still within the refuge boundary); these pits have not received formal closure.

A USFWS study conducted by Rodney Jackson (1990) entitled, *Report of Findings: Kenai National Wildlife Refuge Drill Mud Pilot Study*, assessed the migration potential of drill mud pit materials to surrounding soils. Jackson discovered elevated trace metal concentrations in some samples, but concluded that overall there was no gross contamination. However, drill contents buried in reserve pits still may be a potential contamination source.

The September-December 1959 Annual Narrative offers a historical perspective about the uses of reserve pits and injection wells for drill mud and liquid waste disposal:

> *It appears as though the problem of waste disposal on the Kenai National Moose Range has been surmounted. The past season's cleanup operations indicate the following methods of waste disposal to be the best according to existing site conditions:*
>
> *1) In previously constructed waste sumps (reserve pits), long, deep, narrow pits were dug, using a dragline with a clam bucket. The "jell" (drill mud) was dozed into these pits, followed by a latticework layer of downed timber and brush. Then a layer of earth, three to four feet deep, was hauled in by "Turnapulls" to seal in the mud.*

2) *In new sump construction, the sump pits are either dug long and narrow or rectangular, according to topography. Along one side of the rectangular pits, an additional long and narrow excavation is dug below the bottom level of the sump to facilitate mud disposal during cleanup.*

3) *Liquid waste requires moving before disposal of waste mud can be accomplished. On the Moose Range, a dry hole (Well No. 3) was reopened October 20, 1959, to a depth of 3,200 feet. The casing was perforated 233 feet above this level and liquid waste injected at the rate of 4,000 barrels per day at 1,000 to 1,500 pounds pressure.*
(pages 19-20)

Though reserve pits (now lined) are used less frequently today, they still are permitted and utilized in oil/gas operations on the refuge. In current operations, the majority of drilling wastes are injected underground into injection wells (discussed in the next section). Additionally, SRF and BCF each have a permitted facility for solid waste located on the refuge (page 50).

Swanson River Field has five disposal wells and four enhanced recovery wells. Beaver Creek Field has two disposal wells.

Injection Wells

As previously stated, lined reserve pits currently are used less frequently for storage of drilling muds, fluids, cuttings and produced waters. On KNWR, these substances usually are injected into 2,000+ feet deep disposal and/or enhanced recovery wells. SRF has five disposal wells and four enhanced recovery wells. BCF has two disposal wells. These wells are regulated by the Alaska Oil and Gas Conservation Commission (AOGCC) under the Underground Injection Control (UIC) program (20 AAC 25.252 and 20 AAC 25.402). Any well construction must be permitted by AOGCC. After construction, these wells are monitored regularly and tested for mechanical integrity every four years (yearly in SRF). According to the AOGCC, substances injected into enhanced recovery wells "must be appropriate for enhanced recovery and must function primarily to enhance recovery of oil and gas." These fluids include produced water, snowmelt, hydrotest fluids and treated effluent. According to AOGCC, substances injected into disposal wells must be associated with exploration and development of oil and gas and may include:

1) *any produced fluid as well as fluids circulated through a well as part of drilling, completion, workover, or maintenance activities; examples include muds and cuttings, produced sand and fluids, acids, frac fluids returned from downhole and well freeze protect fluids*

2) *fluids that have come into contact with produced fluids during normal production operations; examples include freeze protect fluids, fluids in surface lines (prior to transportation), detergents or other media used to clean vessels and lines, scale inhibitors or other chemicals added to protect surface lines, spill cleanup material and rigwash*

3) *fluids necessary to facilitate disposal of produced fluids; examples include fresh or seawater, truck rinseates, new or*

used mud, or other additives used to slurrify or otherwise treat waste prior to injection

Because these wells are monitored and regulated, contamination issues resulting from injection practices likely are minimal. However, it is necessary to document this practice as a potential contamination issue.

Explosions

In addition to the SRF compressor plant explosion (pages 9-12), some other oil/gas exploration-related explosions have occurred on the refuge. Due to the seriousness of the compressor plant explosion and the resulting unforeseen contamination issues, other explosions also may have caused unnoticed contamination issues. The explosions listed in this section were documented in the Annual Narratives. It did not appear that these explosions prompted any sort of contaminant investigation.

According to the September-December 1960 Refuge Narrative, two major explosions occurred in 1960:

> *A section of the Alaska Natural Gas Pipeline Company's pipeline ruptured during pressure testing of the completed portion of their line early in the morning of November 17th. The break occurred near the Kenai Spur Road between Soldotna and Kenai. A low, overcast sky reflected the resulting fire, lighting up the area for miles around as though it were day. The line was being tested at 1,000 pounds pressure when it gave way.*
>
> *The second explosion occurred the evening of November 26th at SRU Well 14-27 [at SRF]. During drilling operations, a pocket of gas was encountered which seeped into the drilling building before the blow-out valve was closed. The accumulated gas within the building ignited, blowing out portions of the walls and roofing. Three men were injured requiring evacuation to Anchorage.* (page 19)

Another explosion occurred on March 11, 1981 at SRF. It happened in the emergency generator/boiler room causing extensive damage to the building including electric power and alarm/shut-down systems for Plant 10 compressors.

Substances considered to be relatively innocuous in the absence of heat may chemically transform during explosions and fires into hazardous chemicals (e.g., PAHs, dioxins/furans).

Fires

Fires can cause contamination in a variety of ways. Fires can diminish the integrity of pipes, tanks, and other containment vessels, releasing substances stored within them. Also, substances considered to be relatively innocuous in the absence of heat may chemically transform in the presence of heat into hazardous substances (e.g., PAHs, dioxins/furans). The fires listed in this section were noted in the Annual Narratives. It did not appear that these fires prompted any sort of contaminant investigation.

On March 4, 1962 at SRF, a fire occurred at the SCU 41-4 tank setting causing about $2000.00 loss to dehydration equipment.

On May 27, 1965, the exhaust pipe of a large gas compressor caught fire on SRF. Damage to the building amounted to several thousand dollars.

On July 29 1968 at SRF, refuge staff discovered an unreported fire that burned nearly an acre at Soldotna Creek well site 14-9. Another inspection of SRF on August 15, 1968, located two large unreported oil spills and two unreported fires.

On December 4, 1977 at SRF, a 5,000 bbl water-holding tank collapsed due to corrosion. This incident caused a chain-reaction, which burned and destroyed three 1-33 tank setting buildings and four other tanks. In 1982, the rebuilding of the 1-33 tank setting facilities was completed. Because the 1977 Annual Narrative could not be located, further information on this explosion is not readily available.

By the late 1980s all of the PCB-containing transformers at Swanson River Field were replaced, so they no longer contained PCBs.

Transformers

Residual contamination from PCB-containing transformers may be an issue at SRF (PCB-containing transformers were not used at BCF).

At Swanson River Field on September 15, 1981, a routine inspection of field transformers revealed a transformer crack that caused about two gallons of transformer oil to leak onto the ground. The oil contained 55 ppm PCBs. The oil remaining in the transformer was drained, and the crack was repaired. Oil from a second similar transformer also was drained and replaced. The supporting concrete pad was chipped away, and the gravel was removed. All contaminated material including work clothes, tools and the oil were drummed in 19 containers and shipped outside Alaska for proper disposal. The total cost of this cleanup to the operator was $54,000.

By the late 1980s all of the PCB-containing transformers at SRF were replaced, so they no longer contained PCBs. However, residual contamination may be an issue, if any transformer oil leaked before replacement occurred.

Mercury Manometers

Residual mercury contamination from mercury manometers may be an issue at SRF (mercury manometers were not used at BCF). Manometers are instruments used to measure pressure. For general information about mercury toxicity, please see Appendix E.

As of January 2, 1991 there were 18 active and one out-of-service manometers at SRF. The manometer locations, whether or not mercury contamination was detected and the amount of mercury that was in use at each location are presented in Appendix F.
A letter by Randall B. Kanady, Cook Inlet Environmental Coordinator, to the BLM on January 2, 1991 describes the use of each manometer at SRF:

> *Manometers No. 1-15 are used to monitor compressor engine scavenger air pressure. Manometer 16 is attached to a portable control panel that is used to monitor compressor engine scavenger*

air pressure, if there is a problem with one of the first fifteen manometers. Manometer 17 is used to calibrate non-mercury flow meters. Manometer 18 is used as a level monitor on the wastewater tank at the 1-33 tank setting. Manometer 19 is an out-of-surface calibration unit stored at the electric shop.

According to this letter, minor amounts of spilled mercury were discovered at eleven manometer locations (Appendix F). As of December 12, 1990 most of the mercury was recovered. During the first quarter of 1991 all mercury manometers, except manometer 17, were replaced with non-mercury gauges at SRF. However, residual mercury contamination still may be an issue.

Seismic Exploration
Seismic exploration for detecting oil formations has been conducted over large areas of the refuge, and the refuge maintains files and reports describing the areas where seismic exploration has occurred. Seismic mapping is typically conducted by using explosives. Explosive detonations send shock waves through the rock strata, and sound waves are reflected back to the surface. These sound waves are then detected, recorded and used with geological information to determine likely oil formation locations. Seismic exploration presents more of a habitat degradation/disturbance and wildlife disturbance issue than an apparent contamination issue. However, considering the extensiveness of seismic exploration on the refuge, these operations should be noted. One issue with seismic exploration is the potential for undetonated explosive charges. On September 20, 1993, an undetonated explosive charge was discovered by a hunter along the eastern border of SRF. The charge remained from seismic explorations conducted by Northern Geophysical Company in the winter of 1989-1990.

Summary: Additional Potential Contamination Events and Sources from Oil and Gas Development

Drilling muds and reserve pits, injection wells, explosions, fires, use of PCB-containing transformers, use of mercury manometers and seismic exploration activities are examples of some historic events and past (and current) practices which may have caused some unnoticed contamination issues on the refuge. The contamination potential of these incidents should be considered and contaminants sampling should be pursued if warranted.

Pesticides

In the 1960s, Agent Orange was applied on Kenai National Wildlife Refuge for moose browse improvement.

Historically, pesticides have been used on the refuge to eradicate spruce and tall deciduous trees for moose browse improvement and to prevent fence posts from rotting. Some of the pesticides applied on the refuge were dybar, 2,4-dichlorophenoxyacetic acid (2,4-D), 2,4,5-trichlorophenoxyacetic acid (2,4,5-T) and pentachlorophenol (PCP), all of which will be discussed in further detail in this section. The chemical abstract (CAS) numbers, synonyms, physical/chemical properties, environmental fate characteristics and toxicological effects for each chemical discussed in this section are located in Appendix G.

The first mention of pesticide use on the refuge occurs in the May-August 1954 Narrative, which states:

> *A Federal Aid Project was started to test the value of various herbicides in eradicating spruce and tall deciduous trees for range improvement. Plots were treated by ground sprays on a plot adjacent to the control burn plot on Slikok Lake and in the Chickaloon Bay area. A plot was treated by aerial spraying in the Chickaloon Bay area. Observations on these plots for the season are not yet complete.*
> (page 6)

This is the only information the May-August 1954 Narrative provides. It does not contain specific information concerning which herbicides were used, the amounts applied or the exact locations of use.

Although, the Annual Narratives provide some information about historic pesticide use on the refuge, they may not detail all pesticide uses on the refuge. In fact, the next mention of pesticide use does not occur until 1959.

All known pesticide application events on the refuge, as documented in the Annual Narratives, are listed in Table 1. The narratives did not provide exact application locations in many instances.

Dybar

Dybar (fenuron) was applied at certain locations on the refuge for moose browse improvement in 1959 and 1961 (Table 1). Dybar readily biodegrades in terrestrial environments, with a half-life of approximately two to five months depending on ambient temperature. In aquatic environments, dybar also will biodegrade readily. Additionally, dybar will not bioconcentrate in aquatic organisms. Because dybar was applied on the refuge several decades ago and it rapidly biodegrades in the environment, residual dybar contamination is likely not an issue for the refuge

Table 1. Pesticides Applied on Kenai National Wildlife Refuge as Documented in the Annual Narratives.

Pesticide(s)	*CAS#*	*Dates Applied*	*Application Rate*	*Application Location*
Dybar	101-42-8	June 1959	Unknown	4 test plots
Dybar	101-42-8	April 12, 13 and 19, 1961	10 to 80 pounds/acre (pellet form)	31 plots, 1/10 acre each in 6 cover types*
2,4-D and 2,4,5-T used separately and in mixtures	94-75-7 and 93-76-5	June 1964	Various**	24 plots, 1/100 acre in the Naptowne area
50:50 ratio of 2,4-D and 2,4,5-T (Agent Orange)	94-75-7 and 93-76-5	June 15, 1966	4 pounds/acre in a mixture of 30 gallons of water (aerially sprayed)	10 acre plot directly south of Grus Lake, north of Swanson River

**More information regarding location, cover types treated and treatment results is contained in Appendix H.*
***More information regarding this application and treatment results is contained in Appendix I.*

Dioxin is recognized by the National Toxicology Program as a "known human carcinogen."

There are 75 polychlorinated dibenzo-p-dioxin (PCDD) congeners and 135 polychlorinated dibenzofuran (PCDF) congeners; the number of chlorine atoms can vary from one to eight. The toxicity of PCDD/PCDF compounds is related to chlorine atoms occupying the 2,3,7 and 8 positions.

2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and 2,3,7,8-tetrachlorodibenzofuran (2,3,7,8-TCDF) are considered extremely toxic. 2,3,7,8-TCDD is often called dioxin, even though 2,3,7,8-TCDD is just one of the 75 dioxin congeners. 2,3,7,8-TCDD will be called dioxin or TCDD throughout this document. The plural term "dioxins" will be used when referring to more than one dioxin congener.

2,4-D, 2,4,5-T and Dioxin

The first mention of 2,4-D and 2,4,5-T use occurs in the January-April 1963 Narrative. Apparently 2,4-D and 2,4,5-T were ordered for brush control use during the summer of 1963. However, the narrative does not expand on if and where the chemicals were applied that year. The known application dates, locations and application rates for 2,4-D and 2,4,5-T are listed in Table 1.

The application of 2,4-D and 2,4,5-T has generated considerable controversy due to their extensive use as a defoliant in the Vietnam War. During the war, the U.S. military called a 50:50 mixture of 2,4-D and 2,4,5-T, "Agent Orange," due to the orange stripes on drums which contained this 50:50 mixture.

One major concern with 2,4,5-T is contamination with 2,3,7,8-tetrachlorodibenzo-p-dioxin (dioxin or TCDD). Dioxins are a byproduct of 2,4,5-T manufacturing. The TCDD contamination in Agent Orange ranged from 1.77 to 40 ppm (Moore, http://dns.advnet.net/gdmoore/aotalk1.htm). Dioxin is thought to cause a variety of human health effects and is categorized by the International Agency for Research on Cancer (part of the World Health Organization) as a human carcinogen. Dioxin is also recognized by the National Toxicology Program as a "known human carcinogen." Additionally, dioxin may bioconcentrate in aquatic organisms and is suspected to cause reproductive toxicity in some wildlife species. In 1985, use of 2,4,5-T was banned in the United States due to concerns about dioxin contamination.

Pentachlorophenol

The refuge narratives never detailed any use of PCP on the refuge, and it was not until a 1991 refuge-wide inventory of potentially contaminated sites that PCP contamination was discovered (ADEC spill number 94-23-09-096-02).

PCP was used on the refuge in the 1960s and 1970s to treat fence posts during construction of perimeter fencing for the Moose Research Center, a cooperative moose research effort between USFWS and the Alaska Department of Fish and Game. Precut

Site investigation for pentachlorophenol contamination at the Moose Research Center. USFWS Photo by James E. Frates.

spruce posts were soaked in a mixture of PCP and diesel fuel to prevent the poles from eventually rotting. Prior to being placed in the ground, the butt ends of the poles were soaked in sealed concrete culverts for several days. The treatment location is known as the Swan Lake 1 exploratory well drill site (an abandoned oil well pad drilled in 1961).

The release of PCP and diesel range organics (DRO) at the site occurred from spillage, overflow and drip-drying activities. There are no records to indicate how many culverts were used, how many posts were treated or how much PCP was applied. Soils at the site had PCP concentrations up to 300 ppm. Concrete culverts had PCP concentrations from 3 to 450 ppm. Dioxins and furans were also detected at the site, but TCDD was not one of the dioxins detected.

Currently, the use of PCP is restricted in the United States. Like 2,4,5-T, PCP also is infamous for containing dioxins. PCP contains a wide variety of dioxins (virtually every possible isomer) with the higher chlorinated congeners predominating. The concentration of total dioxins in PCP is in the mid-to-high ppm range, and the primary dioxin congener in PCP is octachlorodibenzo-p-dioxin, which is about as toxic as table salt (Shadoff, http: //www.geocities.com/Athens/1309/d_where2.html).

Cleanup plans were initiated in 1993, and debris and several culverts were removed from the site. In April 1988, ADEC determined the site required no further action. However, according to the ADEC, both DRO and PCP subsurface contamination remain at levels which may pose a human/ecological health risk. To alleviate possible risks, the ADEC mandated the following institutional controls:

1) site access by unauthorized individuals will be restricted by a locked gate

2) the site will not be developed other than to be used as a temporary storage area

3) no groundwater well will be installed at the site; and

4) no activity that may disturb subsurface soils may occur.

Summary: Pesticides

Currently, no pesticides are used on the refuge, and any pesticide use must first be approved by the Pesticide Coordinator at the USFWS Regional Office in Anchorage, Alaska.

Although several pesticides were applied at the refuge, it is possible that these chemicals have degraded over the years and no longer pose contamination threats. One concern, however, is the persistence of dioxin in the environment. Dioxin is considered resistant to biodegradation, and half-lives in soil interiors are estimated at 12 years (http://www.speclab.com/ compound/c1746016.htm) and perhaps longer in colder climates, like Alaska. Dioxin contamination could still be an issue in areas where 2,4,5-T was applied.

Formerly Used Defense Sites

Some military activities have occurred on or near the refuge. This section contains a description of known formerly used defense sites (FUDS), known military activities and a discussion of potential contamination issues.

Skilak Military Recreation Site

The Skilak Military Recreation Site was located on the refuge 1/4 to 1/3 mile downstream of the outlet of Skilak Lake on the north side of the Kenai River (Figure 5, star indicates approximate location). This site was used by the military as a recreation area in the 1940s and was transferred to the USFWS in 1954. Prior to 1988, over 70 empty drums were removed from the site and several extremely rusted barrels still remain at this location. To date, this site has not been tested for contamination. Considering the area's history and the large number of barrels removed from this site, a contaminants investigation by the U.S. Army Corps of Engineers FUDS program may be warranted.

Figure 5. Approximate Location of the Skilak Military Recreation Site.

Naptowne Radio Relay Site

The 19.5-acre Naptowne Radio Relay Site is located on the north side of the Sterling Highway at milepost 78.1. The U.S. Air Force established this site in 1955 for a microwave radio relay station as part of the White Alice Communications System (WACS). The site contained a power and equipment building, steel tower, warehouse, sanitary latrine, fuel storage tanks, chain link fence and access road. Additionally, gravel removal occurred at the site. The Air Force had a special use permit issued by the USFWS for this site until September 1982. In November 1983, Alascom, Inc. took over the site from the Air Force, and Alascom was issued a special use permit by USFWS. Alascom is the current operator of this site.

Many WACS sites in Alaska are known to be contaminated. Because this was a WACS site, potential contamination issues could exist, especially if PCBs were used in conjunction with power generation. In December 1987 and January 1988, Alascom's contractor reported finding no evidence of hazardous/toxic waste, ordnance or unsafe debris. It is unclear how detailed of an assessment occurred at this site, and a reevaluation of possible contaminants and sampling by the U.S. Army Corps of Engineers FUDS program may be warranted.

Turnagain Arm Firing Range

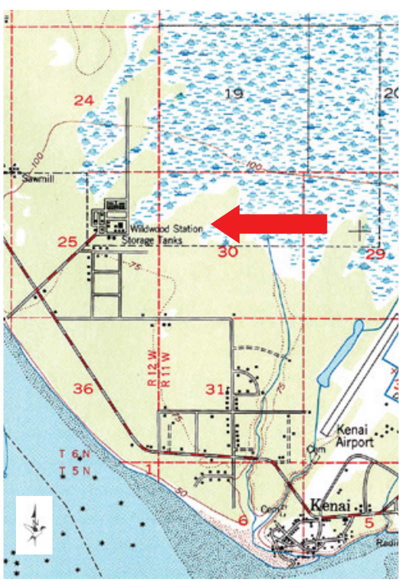
In 1955, the Department of the Army established the 47,864-acre Turnagain Arm Firing Range, which was to be utilized as an anti-aircraft artillery firing range. The site was located in Southcentral Alaska approximately six miles south of downtown Anchorage on both sides of the Turnagain Arm; 99% of this site was located on what is now the KNWR. However, in 1957 the Army decided not to develop the firing range, and all available information indicates the site was never used for its intended purpose.

According to Rick Johnston, a Ranger and Pilot for the refuge, in 1990 approximately 8 to 15 barrels were observed in an open meadow in Chickaloon Flats, south of Chickaloon Bay and West of Chickaloon River. These barrels were located within the proposed Turnagain Arm Firing Range. The exact location of the barrels was not recorded, and the barrels were never sighted again. Johnston thought the barrels probably belonged to the military.

Wildwood Station

The Wildwood Station was an Army base located 3.5 miles north of the city of Kenai, approximately 3 miles west of the refuge boundary (Figure, 6, arrow pointing toward Wildwood). It was constructed and used as a communications station by the Army in 1953. On December 31, 1965, this site was activated as Wildwood Air Force Station and was closed on July 1, 1972. The site comprised 5,300 acres, with military construction on 70 acres. The site included three aboveground fuel tanks, 12 underground fuel tanks, various structures and three abandoned landfills.

Figure 6. Approximate Location of Wildwood Station.



In the late 1980s, studies were initiated at Wildwood to determine potential contaminants and contaminated areas. The primary contaminants of concern were determined to be fuels and lead; however, other contaminants such as PCBs, dioxins, dichlorobenzenes, methoxychlor, endrin, BTX, dichlorodiphenyltrichloroethane (DDT) and chlordane were also discovered at the site. Since 1993, many cleanup actions have occurred. According to Jim Baker, Engineering Manager for the U.S. Army Corps of Engineers, no contamination is migrating toward the refuge (pers. comm.).

Other Military Activities

Historically, the refuge was used for military maneuvers, but the full extent of past military maneuvers on the refuge is unknown. One such event is documented in the January-April, 1959 Refuge Narrative:

> *Some two hundred men of the 1st Battalion, 23rd Infantry, from Fort Richardson, Alaska, conducted maneuvers on the Range March 26 and 27. From a point of helicopter landing on the*

> *Chickaloon River flats, ski troops traveled overland to Sterling via the Moose River. At Sterling, they joined other motorized troops in a sham attack on Wildwood Station, Kenai.*
> (page 9)

Additionally, several permits were issued for temporary military camps on the refuge. In 1953, the Seward Army Recreational Center maintained temporary camps on Hidden Lake and on Lower Russian River for periods during the summer. It is unclear how many of these temporary camps existed and what activities transpired at these camps; however, they likely were used just for recreation and thus pose little concern from a contaminant standpoint. There is no known evidence of contamination on the refuge resulting from these activities.

Summary: Formerly Used Defense Sites

Although some military activities have occurred on or near the refuge, it is unknown if any potential contamination issues exist. Based on current knowledge of military activities, it appears that the former Skilak Military Recreation Site and the Naptowne Radio Relay Site would be the most likely locations for potential residual contamination.

Development Near the Refuge Boundaries

The KNWR is more impacted by urbanization than any other refuge in Alaska.

Development and urbanization near the refuge boundaries may pose potential contamination issues for the refuge. Several potential contamination sources exist due to increased urbanization including the following: air pollution from motorized vehicles and industry; stormwater drains and other discharges emptying into water sources including the Kenai River and its tributaries; chemical spills along roadways; power lines; and other point and non-point sources of pollution.

The KNWR is more impacted by urbanization than any other refuge in Alaska, due to its accessibility and its proximity to Anchorage, the most populated city in Alaska, with a population of 259,391 (July 1, 1999 estimate by Alaska Department of Labor and Workforce Development, http://www.labor.state.ak.us/news/news0013.htm). Additionally, Kenai, Soldotna and Nikiski are three growing cities within minutes of the refuge boundaries. According to the Alaska Department of Labor and Workforce Development as of July 1, 1999, Kenai's population was 7,005, Soldotna's was 4,140 and Nikiski's was 3,038 (http://www.labor.state.ak.us /news/news0013.htm). It also should be noted that the City of Soldotna landfill is within ¼ mile of the refuge boundary.

Industrial Sources

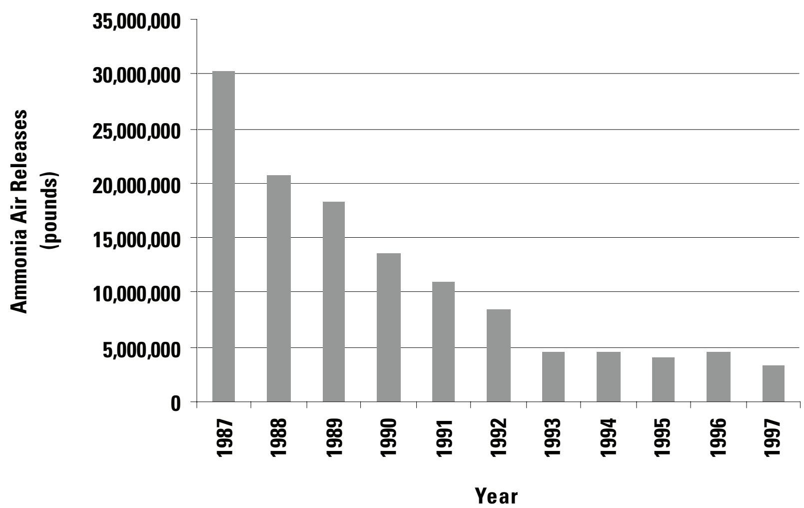
An industrialized area exists near the northwestern portion of the refuge boundary along the Spur Highway from Kenai to Nikiski. Major industrial sources include the Tesoro Refinery, in operation since 1969; Phillips Petroleum, a liquefied natural gas (LNG) processing facility that has been in operation since the late 1960s; and Agrium (formerly Unocal Agricultural Products Facility), which opened in 1969 and refines natural gas into urea and ammonia fertilizer.

Agrium facility. USFWS Photo by Tiffany A. S. Parson.

In 1997, the Unocal Agricultural Facility (now Agrium) released more air emissions than any other facility in Alaska, emitting 3,481,219 pounds of chemical (96% ammonia).

One concern noted by refuge personnel is the release of ammonia from the Agrium facility. The ammonia air releases from 1987 to 1997 are displayed in Figure 7. According to the 1997 Toxics Release Inventory (TRI), this facility released more air emissions than any other facility in Alaska, emitting 3,481,219 pounds of chemical (96% ammonia). Historically, plant upsets caused releases of ammonia above permitted levels (ENVIRO, Unocal Speaking of the Environment, January 1998). However, since 1986, Unocal has worked to continually reduce their ammonia emissions through system upgrades and installing flares. According to a Unocal publication entitled ENVIRO, Unocal Speaking of the Environment (June 1999), "flares have dropped ammonia releases due to plant upsets by 97 percent." Potential impacts of these historic and ongoing ammonia releases on refuge resources are unknown.

Figure 7. Ammonia Air Releases from Unocal Agricultural Facility (now Agrium) from 1987 to 1997.



Source: Toxics Release Inventory, 1997.

Air Quality

The refuge is designated as a Class II air quality area, and air quality has become an increasing concern over the years. Several sources may be contributing to diminished air quality such as vehicular and industrial emissions including sources in Anchorage and on the Kenai Peninsula. With continued development and urbanization, these sources will increasingly affect air quality. Air quality issues and concerns are discussed in several of the refuge narratives. Refuge personnel note that during clear cold weather a brown haze is often seen over Cook Inlet and the northern lowlands of the Refuge.

Stormwater Drains and Other Discharges

Numerous stormwater drains from the cities of Sterling, Soldotna and Kenai discharge directly or indirectly (though tributaries) into the Kenai River. A two year water quality study on the Kenai River conducted by Litchfield and Kyle (1992) found that river water samples taken from two storm drains at river mile (RM) 17.7 and

21.8 had a surface sheen and TPH concentrations of 1,300 and 2,600 mg/L, respectively (samples were taken after a rainfall). The storm drain at RM 17.7 drains several streets in the vicinity of Marydale Drive. The storm drain at RM 21.8 drains part of the Sterling Highway and several streets. This storm drain enters the river behind the State of Alaska Department of Transportation maintenance facility.

According to ADEC water quality standards 18 AAC 70.020 (May 27, 1999), "petroleum hydrocarbons, oil and grease may not cause a film, sheen or discoloration of the surface or floor of the waterbody or adjoining shorelines; surface waters must be virtually free from floating oils" for fresh water used for recreation.

Since the early 1990s, the cities in the Soldotna area have been proactive by providing various treatment systems for many of the storm drains, including the Marydale storm drain at RM 17.7. At this time, the storm drain at RM 21.8 does not have a treatment system (Dave Johnson, ADEC, pers. comm.). According to ADEC employee, Gregory Drzewiecki, currently there is no State water quality person for the Kenai Peninsula, and the storm drain discharges entering the Kenai River are not required to be monitored. Although these cities are primarily downstream from

The Kenai River is an invaluable resource for the Kenai National Wildlife Refuge. USFWS Photo by James E. Frates.

the refuge, contaminants entering the Kenai River from storm drains may impact trust species which inhabit/utilize the river.

A two-year study by Litchfield and Kyle (1992) also discovered that the lower more urbanized portion of the Kenai River in the Sterling/Soldotna/Kenai area had elevated concentrations of TPH and fecal coliform, when compared to the upper relatively undeveloped portion of the river. Additionally, benthic invertebrate populations were different between the upper and lower river, but there was no evidence that these differences were related to contaminants. The results of their study suggest that increased urbanization is impacting water quality in the more urbanized portions of the Kenai River.

Sterling Highway and Other Roadways

The transport of hazardous materials along the Sterling Highway and other roadways makes the refuge vulnerable to potential contamination events.

The Sterling Highway cuts through the heart of the KNWR and crosses approximately 21 miles of refuge lands. Vehicle emissions may pose air quality issues for the refuge. Stormwater runoff, snowmelt and road salts also may impact refuge resources. Additionally, the transport of hazardous materials along the Sterling Highway and other roadways makes the refuge vulnerable to potential contamination events. One example of a spill, which occurred along the Sterling Highway, was documented in the 1985 Annual Narrative. A 5,900 gallon unleaded gasoline spill was the result of a truck-trailer accident near Jean Lake (about Mile 61 of the Sterling Highway) on December 5, 1984. Some of the gasoline apparently reached Jean Creek, and absorbent booms and pads were used to trap the fluid. In June, a site investigation was conducted and trace of fuel were detected at the site.

Power Lines

Due to urbanization on the Kenai Peninsula, power transmission lines have been installed on refuge lands. The refuge narratives document environmental disturbance and insufficient habitat rehabilitation/restoration associated with power line installation in the late 1950s and throughout the 1960s. It appeared that habitat degradation issues rather than contaminant issues were the primary concern. One concern with power transmission, in general, is the potential presence of PCBs in transformers. Currently, no problems have been documented regarding PCBs and power line easements on the refuge.

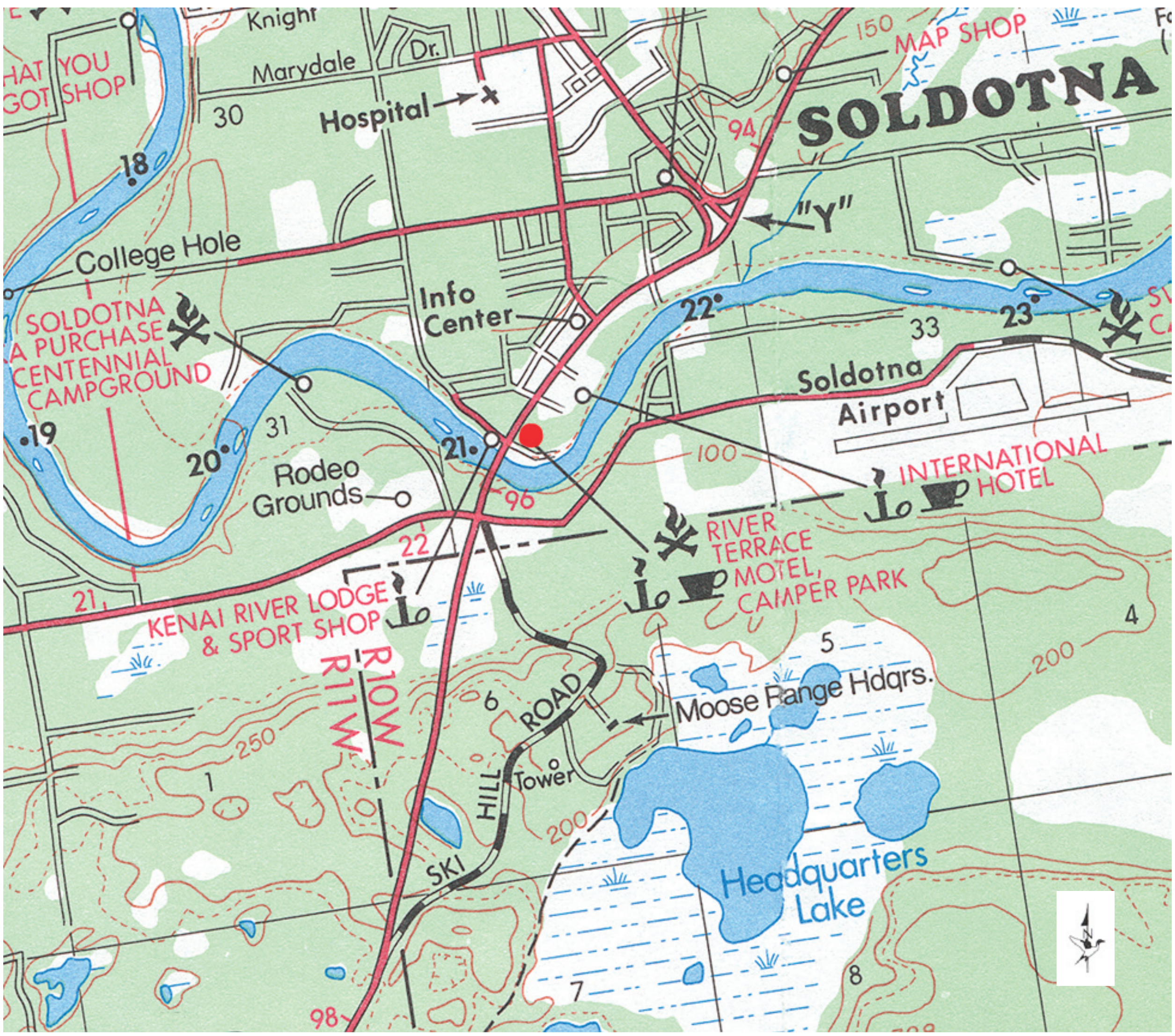
Other Sources

Due to increased urbanization, other point and non-point sources may have contaminant impacts on the refuge and its resources. One example is a contaminated site in Soldotna at the River Terrace Recreational Vehicle (RV) Park about half a mile downstream from the Refuge boundary (red circle indicates approximate location, Figure 8). A citizen’s complaint in 1992 about leaking barrels at the site was the impetus for a site investigation. Some of the analytes detected at the site are tetrachloroethene (PCE) and its degradation products including trichloroethene (TCE), dichloroethene (DCE) and vinyl chloride (VC), DRO and TPH. The contamination is thought to be from a former dry cleaning operation. In the late 1960s, a laundry facility and dry cleaning operation were located at this site. In the late 1980s, the dry cleaning operation closed; however, the laundry facility currently remains open. The site was added to the ADEC database in June 1996; the ADEC spill number is 1992230918701.

The site cleanup started in 1997, and it has been a controversial and arduous process. Contamination at this site has impacted soil, groundwater and Kenai River surface water and sediments. While this site is downstream of the KNWR, the Kenai River is an invaluable resource to the refuge, and contaminants entering the Kenai River may impact trust species which inhabit/utilize the river.

In 1997, a comprehensive soil sampling process at the site revealed PCE concentrations at surface soil levels up to 4,700 ppm (ADEC, April 1997). PCE was detected down to 35 feet at 0.910 ppm (ADEC, April 1997). Sediment samples (May 1997 and May 1999) and surface water samples (May 1999) from the Kenai River indicated the presence of PCE and some of its breakdown products. In one

Figure 8. Approximate Location of the River Terrace Recreational Vehicle Park.



Alaska Road and Recreation Maps, 1980.

surface water sample, PCE was detected at 2.5 ppb, approximately one-half the acceptable Safe Drinking Water Maximum Contaminant Level (MCL) of 5 ppb for PCE (18 AAC 70) in Kenai River surface water (Oasis/Bristol Environmental Services, 2000). Some sediment samples were above sediment quality benchmarks (SQBs) for PCE, TCE and Cis-1,2-dichloroethene (Cis-1,2-DCE) (Oasis/Bristol Environmental Services, 2000). Additionally, PCE is reaching the Kenai River through stormwater discharge. Apparently, contaminated groundwater is moving from the RV site beneath the Sterling Highway to the stormwater sewer system. At the outfall, PCE concentrations are approximately three to nearly five times greater than the MCL (Oasis/Bristol Environmental Services, 2000). Cleanup and monitoring activities are ongoing at areas impacted by this site. Pilot studies for the remediation of contaminated groundwater will begin in Summer 2000. For further information about this site, please contact Rich Sundet, ADEC Project Manager, at (907) 269-7578.

Summary: Development Near the Refuge Boundaries

Increased urbanization may contribute contaminants that potentially impact the refuge and its resources. Due to the location of the refuge and its accessibility, development likely will increasingly affect refuge lands and may impact fish and wildlife and their habitats.

Mining

Historically, mining occurred on the Kenai National Wildlife Refuge. Some of these old mining sites may present contaminant issues for the refuge.

Mining has occurred on the Kenai Peninsula for several hundreds of years, initially by Native peoples, later by the Russians in the 1800s and then by thousands of miners during the gold rush era. This section will address mining claims on the refuge, historic mining sites and contamination associated with these sites.

Acquiring mining information for the refuge has proven to be a time-consuming and complex process. Several steps were involved to track down the most complete mining information available. This process was summarized by Parson (2000) in a flowchart entitled, Mining Information for Alaska (Appendix J). This chart describes the process used to acquire mining information for the KNWR.

Mining historically has occurred on the KNWR. There were 23 active claims on the refuge as of 1976; however, none of these claims remain active. Additionally, there were at least 32 historical claims on the refuge, which were primarily gold placer claims. It is important to note that just because a *claim* existed, it does not mean an actual *mine* necessarily existed (or that mining activities ever occurred).

Overall, most historical mining ventures on the refuge appeared to be small-scale and likely pose minimal contamination issues. However, some operations, even though small-scale, may have resulted in some degree of contamination from fuels, etc. One concern with gold mining is mercury contamination. Historically, mercury was widely utilized as an amalgam to separate gold particles from river sediment.

In August 1987, 55-gallon barrels were airlifted from the Surprise Creek in Kenai Wilderness. USFWS Photo by Richard K. Johnston.

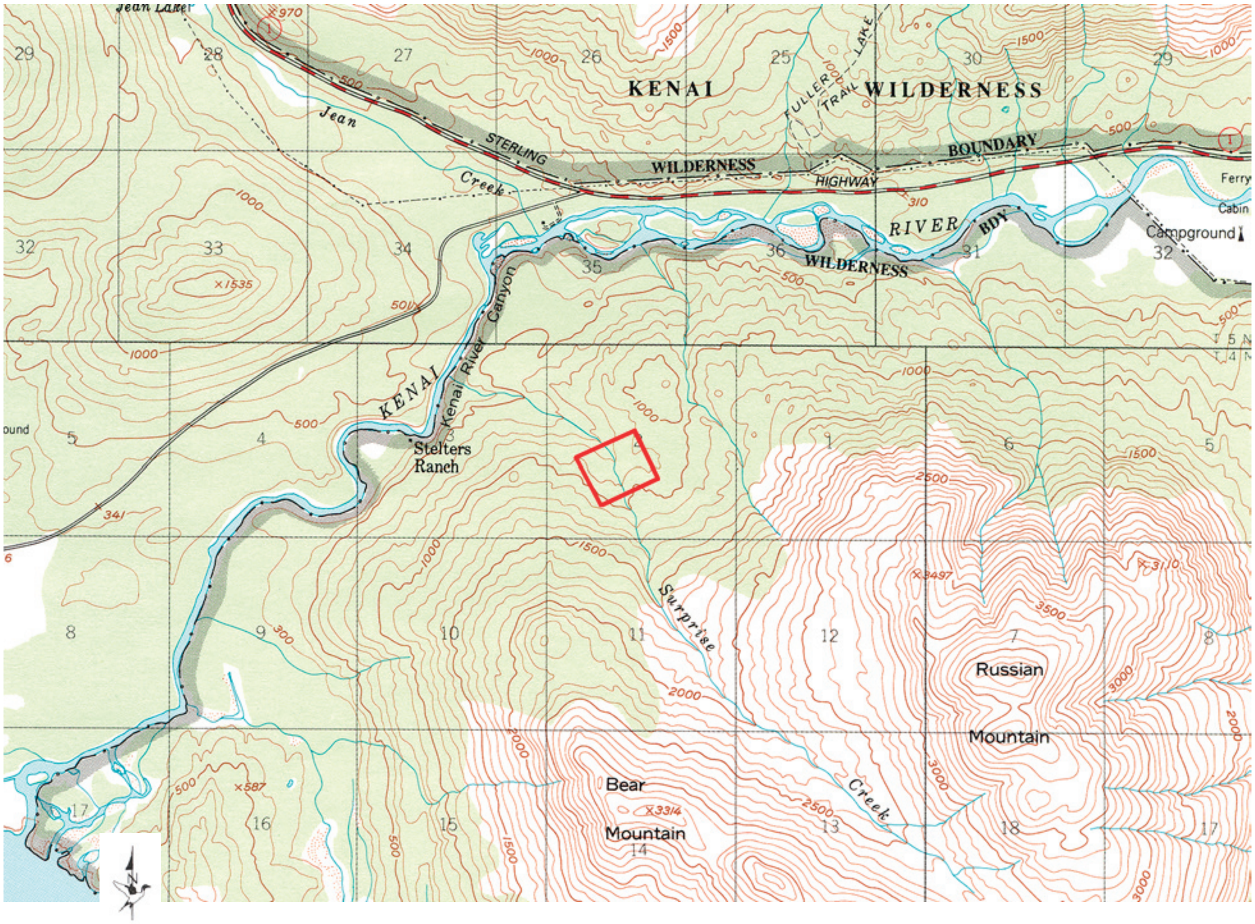
Surprise Creek Gold Mining Site

One known gold mining area with potential contamination issues is located in the Surprise Creek area of the Kenai Wilderness (approximate area denoted by the box, Figure 9). Several cabins associated with mining activity are located in this area.

A drum removal occurred at this site on August 3, 1987. Two dozen 55-gallon barrels were removed by helicopter; at least half of the barrels were full of oil and several were leaking. Due to logistics, all of the barrels were not removed in 1987, and a recreationalist's complaint to the ADEC prompted another removal effort on May 12, 1994. During this effort, four drums of diesel fuel and several empty drums were removed from the site. The drums and other mining items had been there since the 1960s.

A more recent reconnaissance of this gold mining area occurred on October 22, 2000 by Gary Titus, a KNWR Backcountry Ranger. Some of the items he discovered at the site included the following: welder/generator; model-T compressor; tank (air compressor) measuring two-foot in diameter by six foot five inches in length with a manufacture tag located on the side saying "Montag stove and

Figure 9. Approximate Location of Surprise Creek Gold Mining Area.



furnace work Portland Oregon working pressure 128 lbs;" a tank (air compressor) measuring one-foot eight-inches in diameter by four-foot two-inches in length with the words "Deluge Chemical" written on the side; three 55-gallon drums (two empty and one with a few gallons of fuel) with "Alaska Diesel" printed on the end of the drums; two full 10-gallon drums labeled "carbide;" stacks of lumber; riveted mining pipe and other mining equipment; and a water wheel. Most of these items were located within 25 feet of Surprise Creek. Titus also noted that a mining shaft is located in the area, which could potentially pose a physical safety hazard.

Some contaminants of concern at this site include mercury, cyanide, PCBs and calcium carbide. Additionally, explosives are a potential concern at this site. PCBs could be present in Alaska Diesel because additives, such as PCBs, were often added to Alaska Diesel. Calcium carbide was used in headlamps and other portable lighting systems. When calcium carbide is exposed to moisture, acetylene gas is produced. According to the material safety data sheet (MSDS) for calcium carbide, acetylene is rapidly produced from carbide and water and is considered hazardous because of its flammable and explosive properties (http://svis.org/caving/wvusg/calcium.htm).

Fifty-five gallon barrels at the Surprise Creek gold mining area prior to removal efforts in 1987. USFWS Photo by Richard K. Johnston.

A contaminants investigation has never occurred at this site. Due to the history of this site, the potentially hazardous substances identified at the site, and the prior removal efforts, a contaminants investigation may be warranted.

Indian Creek Mining Area

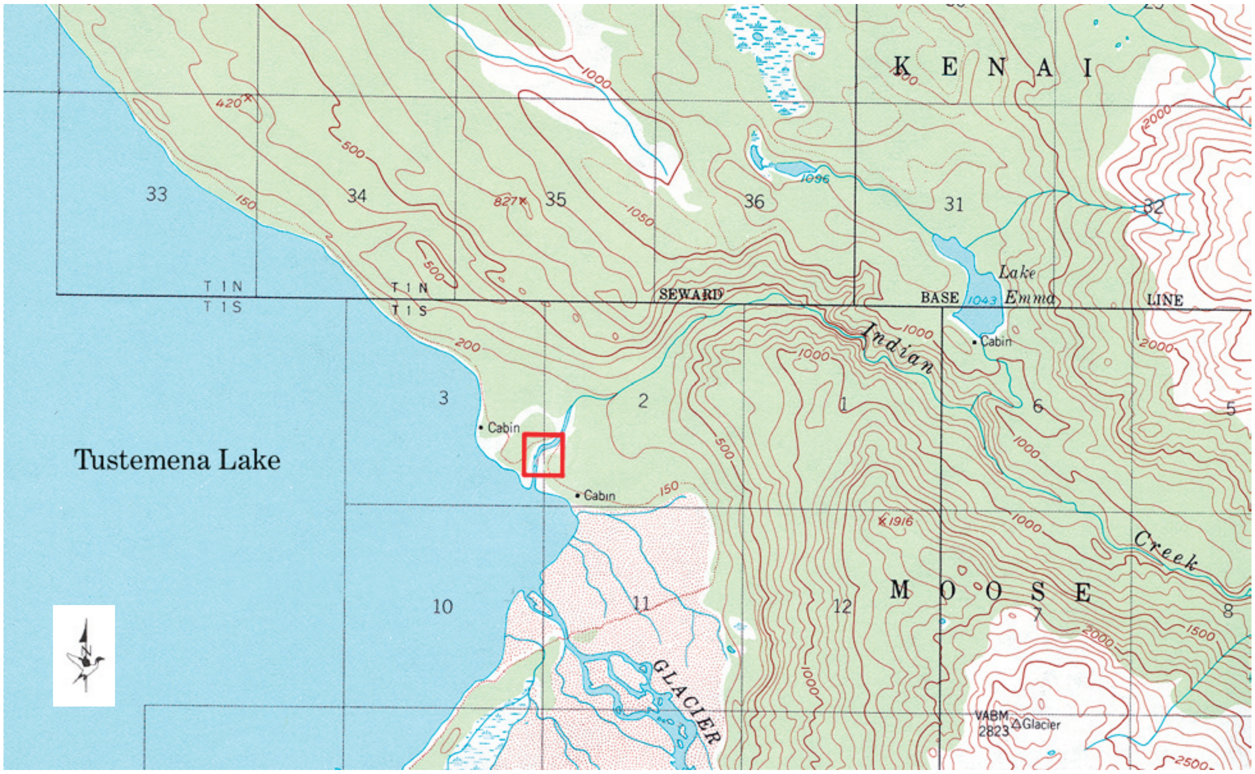
Historically several people mined gold in the area where Indian Creek enters Tustemena Lake (approximate area denoted by the box, Figure 10). At this time, little information is available about possible contaminant concerns resulting from this mining activity.

Other Mining Locations

Debbie Corbett, a USFWS archaeologist, has documented numerous prehistoric and historic sites on KNWR. Some of these sites include mining locations, homesteading sites and old cabins. The locations of these sites on the KNWR have been mapped using ArcView®. Also, Corbett and Maggi Arend, a USFWS Natural Resource Planner, have written a document entitled, *Kenai National Wildlife Refuge, Cultural Resource Guide* (December 1996). Most of these historic sites likely do not present contamination issues for the refuge, but they may provide location information for mining and other activities that have occurred on the refuge. In fact, many of these sites may qualify for protection under federal laws as archeological resources. For further information about these sites, please contact Debbie Corbett at (907) 786-3399.

Although it does not appear that large-scale mining operations occurred on the refuge, mines bordering the refuge boundaries may pose potential contamination issues. Historically, there were thousands of miners in the Hope, Sunrise, Resurrection Creek and Cooper Landing areas (Corbett and Arend, 1996). These areas, situated on National Forest Service (NFS) lands, are located near the northeastern portion of the refuge boundary. Contamination

Figure 10. Approximate Location of Indian Creek Gold Mining Area.



from historic or current mining operations on these lands may enter the refuge's watersheds. According to Carol Huber, a Forest Geologist for the NFS, there has been extensive gold mining and mercury use on Resurrection Creek. Resurrection Creek, although near the refuge boundary, does not flow into the refuge. One area Huber suggested that may pose potential contamination issues for the refuge is Cooper Creek, which flows into the Kenai River approximately 3 miles upstream from the refuge boundary. According to Huber, gold mining and mercury use were extensive in this area.

Summary: Mining

At present, the Surprise Creek gold mining area appears to be the only known mining site on the refuge with potential contamination issues. Other areas which may justify further investigation include the Indian Creek mining area and Cooper Creek.

Waste Disposal

This section will discuss past and current practices of waste disposal at the refuge and contamination issues associated with these practices.

Waste Burial and Repository

For decades, the most common method of trash disposal on the refuge was burial. Additionally, wastes were deposited in repositories on the refuge.

Until 1965, seismic crews were allowed to bury their trash on the refuge, to the point where the unearthing of trash near winter seismic camps by bears became a problem. Additionally, the refuge narratives document trash burial in the 1960s by USFWS personnel at the refuge campgrounds.

Since the establishment of the range/refuge in 1941, an area known as the "Skilak Boneyard" located at the Skilak Guard Station, was a repository for old signs, lumber, pipe, fuel drums, etc. (star indicates approximate location, Figure 11).

Over the years, this site has been used by the refuge, BLM, the State of Alaska and the military during WWII. Historically, the Guard

Figure 11. Approximate Location of the Skilak Boneyard.

Liquid-filled 55-gallon drums at the Skilak Boneyard prior to proper removal and disposal. USFWS Photo by Robert A Richey.

Station also was used by the BLM to accommodate seasonal fire personnel and was utilized as a helicopter refueling base. Currently, the Guard Station is used for housing USFWS seasonal personnel.

In 1988, refuge personnel initiated a large-scale cleanup at the boneyard. During cleanup efforts, 47 drums with various contents were discovered; 31 drums were full or partially full. Two of the drums contained pentachlorophenol (PCP). In 1992, 300 cubic yards of soil were excavated and then remediated by land spreading. All drums were disposed of in accordance with State and Federal regulations. On December 30, 1993, ADEC determined no further action was needed at the site and approved site closure.

Recreational vehicle dump station and lagoon. USFWS Photo by Tiffany A. S. Parson.

Recreational Vehicle Dump Station and Evaporation Lagoon

Due to increasing recreational use on the refuge, an RV dump station and lagoon were constructed in 1993. The dump station and lagoon are located eight miles from the west entrance of Skilak Loop Road. The well is operated by a remote solar-powered generating system with liquid and solid wastes being gravity-fed into an open lagoon system. Although a fence surrounds the open lagoon, wildlife still could enter this area. The lagoon is lined, and there is no apparent evidence for leaching. Fecal coliform, total coliform, sewage, urea, other nitrogenous compounds and chemicals used to treat sewage can negatively impact water quality and human health, thus if the lagoon liner was ever breached, groundwater in the area could be negatively impacted.

Waste Disposal at Swanson River and Beaver Creek Fields

Over the years, an unknown quantity of waste has been buried at the oil and gas fields. Due to the age of SRF, waste burial was likely a common method of disposal until environmental regulations tightened in the 1970s. During PCB and xylene cleanup activities

Solid waste facility at Swanson River Field. USFWS Photo by Tiffany A. S. Parson.

A closer look at one section of the Swanson River Field solid waste facility. USFWS Photo by Tiffany A. S. Parson.

at SRF, previously buried wastes were "discovered." In June 1989, while excavating PCB contaminated soils at SRF, a 300-gallon underground storage tank (UST) was discovered and removed at the Therminol building. Also, during xylene cleanup efforts in 1998 and 1999 at the Pipe and Supply Yard, buried metal debris was unearthed. Some of the metal debris was thought to be from the compressor plant explosion in 1972 because some PCB contamination was discovered.

It was not until 1986 when a solid waste disposal facility was constructed at SRF. The 1-33 skim pit was used historically as a repository for SRF liquid wastes since the late 1950s, and it was not until 1990 when this facility was dismantled and replaced with an advanced separation facility. It should be noted that some concrete from the dismantled 1-33 skim pit was contaminated with PCBs; proper disposal occurred upon removal.

According to refuge personnel, prior to 1988 solid wastes were never permanently stored at BCF. Wastes were held in large plastic totes and when filled, they were taken off site for proper disposal. However, in 1988 waste disposal cells were constructed at BCF. SRF and BCF keep lists of the disposal contents.

Solid waste facility at Beaver Creek Field. USFWS Photo by Tiffany A. S. Parson.

Summary: Waste Disposal

Although solid waste inevitably has been buried on the refuge, the exact burial locations are mostly unknown. Even if these locations were known, in some instances it may cause more damage to the refuge to exhume the debris than to leave it buried.

Recreational Uses

The Kenai National Wildlife Refuge receives more recreational use than any other refuge in Alaska.

The refuge is used for a variety of recreational purposes. It receives more recreational use than any other refuge in Alaska due to its accessibility and proximity to Anchorage. Some of these recreational uses may pose potential contaminant concerns for the refuge. The topics addressed in this section include hunting, fishing, snowmobile use and boating.

Hunting and Fishing

Residual lead from shot and fishing weights/jigs may pose potential contamination issues. From the 1970s to 1991, the use of nontoxic shot eventually was implemented for waterfowl hunting in the United States, but lead from shot still persists in the environment. Fishing weights and jigs are also potential sources of lead. Intensive fishing occurs in several areas on the refuge, especially the Kenai River. Because anglers are so numerous, the sport is often called "combat fishing."

Currently, the refuge is in the process of implementing several lead-free fishing areas. By 2001, anglers will be unable to use lead sinkers or jigs in fishing areas designated as lead-free. These lead-free areas include the Kenai River, for the first three miles below Skilak Lake, and the Swan Lake and Swanson River Canoe Systems.

The refuge narratives only document one account of lead-related wildlife toxicity, which occurred in 1990 when a bald eagle (*Haliaeetus leucocephalus*) died of acute lead toxicity. According to Jill Birchell, a USFWS Special Agent, two more bald eagles died of lead poisoning near the refuge in 1997.

Snowmobile Use

"A snowmobile operating for 4 hours, using a conventional 2-stroke engine, can emit between 10 and 70 times more carbon monoxide and between 45 and 250 times more hydrocarbons than an automobile driven 100 miles."

National Park Service 2000

Snowmobile use and recreation have grown increasingly popular on the refuge. During the winter, it is estimated that several hundred snowmobilers utilize the refuge each weekend. One area that receives considerable snowmobile activity is Caribou Hills. This increased snowmobile activity concerns some refuge personnel. Recently, issues have arisen about air pollution and snowmobile emissions in other federally managed areas, such as Yellowstone National Park. In fact, diminished air quality from snowmobiles has prompted the National Park Service (NPS) to ban private snowmobile use in Yellowstone and Grand Teton National Parks by 2003-2004. Even though the scale of snowmobile use is much greater in Yellowstone National Park, snowmobile emissions may pose air quality issues for the KNWR.

Snowmobiles have two-stroke engines that emit more hydrocarbons (HC) and particulate matter (PM) than vehicles with four-stroke engines, such as automobiles (NPS, 2000). Snowmobiles also emit other pollutants including VOCs, nitrogen oxides (NOx) and carbon monoxide (CO). According to a study by the NPS (2000), "[w]hen compared to various automobile emission estimates, a snowmobile

Combat fishing. USFWS Photo.

operating for 4 hours, using a conventional 2-stroke engine, can emit between 10 and 70 times more CO and between 45 and 250 times more HC than an automobile driven 100 miles" (page 2).

Boating

Motorized boating also has increased steadily on the refuge. However, in several areas motorized boats are not allowed. Some areas closed to motorized boats are lakes within the Canoe Lakes Unit of the Kenai Wilderness and sections of the Kenai River. In some portions of the refuge where boat use is allowed, there are horsepower and no-wake restrictions. According to refuge personnel, the Kenai River receives the most motorized boat traffic on the refuge. The primary concern is two-stroke motors, which emit contaminants to the environment by direct discharge of fuel and incomplete combustion of fuel. A two year water quality study on the Kenai River and its tributaries conducted by Litchfield and Kyle (1992) revealed that gasoline components, BTEX, were elevated in some samples during the peak boating months of June and July, when compared to May and August.

Summary: Recreational Uses

The refuge is utilized for a variety of recreational purposes. It receives more recreational use than any other refuge in Alaska due to its accessibility and proximity to Anchorage. Some recreational uses may pose potential contaminant concerns for the refuge.

Fires and Fire Retardants

Over the years, numerous fires (500+) have occurred on the refuge. The primary contaminant concerns from fires are the production of polycyclic aromatic hydrocarbons (PAHs) from the incomplete combustion of organic material (trees, grass, etc.) and the use of fire retardant chemicals to suppress fires.

Most of the fires on the KNWR were small and usually started by campfires. However, in 1969 two major fires (10 total for the year) burned significant portions of the refuge. The Russian River fire started at a campfire on June 14, 1969 and burned 2,300 refuge acres until it was declared out on July 25, 1969. Over 1,000 men and nearly $1 million were used to suppress this fire. The 1969 Refuge Narrative did not indicate if fire retardant chemicals were used to combat this fire.

The 1969 Swanson River fire burned 83,000 refuge acres. Over 4,000 men and $20 million were used to combat the fire. Additionally, about one million gallons of the fire retardant Phoschek were applied aerially to suppress the fire.

The other major fire, the Swanson River fire, started on August 3, 1969 from a campfire on the bank of the Swanson River. The fire burned 83,000 refuge acres, and over 4,000 men and $20 million were used to combat the fire. Nearly one million gallons of the fire retardant Phoschek (also known as Phoscheck or Phos-chek) were applied aerially to suppress the fire. The MSDS for Phos-Chek® Fire Retardant Grades D-75F and D-75R is contained in Appendix K. Toxicity information for phos-check will be discussed later in this section; however, the grade of phos-chek applied at the Swanson River Fire was not documented. Pictures in the 1969 Narrative show standing pools of phoschek near Mosquito Lake from the Swanson River Fire. The narrative also documents a fish die-off in Swanson River during the fire. On December 21, 1999, one of the biologists who was at the scene of the fire and die-off event, David Watsjold, presented his recollection of the events:

> *I clearly recall the great Swanson River fire of 1969. After the fire was brought under control, Larry Engel and I got into a canoe near the oil field road and went down the river to Cook Inlet. The fire burned very hot on both sides of the river in several areas, and there was virtually no vegetation along the riverbanks. There was extensive use of fire retardants on this fire, and it was evident along the river. It was obvious that some amount of retardant went directly into the river. We had no fish sampling gear with us; we didn't have much in those days. The fire occurred during the peak of the adult coho salmon return. I can distinctly remember that we saw a large number (hundreds) of dead adult coho salmon in the area of the burn and below it. We did not see any small juveniles as they were probably not visible or there was not much rearing going on in the lower river. No adults were collected to determine death, and I don't think we knew at the time what effects retardant had on fish.*

Table 2. 96-hour LC50[a] (mg/L) of Fire-Trol LCG-R and Phos-Chek D75-F to Five Life Stages of Rainbow Trout (Oncorhynchus mykiss) Exposed in ASTM[b] Soft (42 mg/L $CaCO_3$) and Hard Water (163 mg/L $CaCO_3$) at 12±1°C.

Chemical	*Water type*	*Egg*	*Embryo-larvae*	*Swim-up fry*	*60 dph[c]*	*90 dph*
Fire-Trol LCG-R	Soft	>10,000 A	>3,600[e] B	910 C (722-1,115)	1,080 CD (880-1,353)	1,413 D* (1,105-1,724)
	Hard	>10,000 A	2,642[e] B (2,117-3,249)	872 C (685-1,066)	1,413 D (1,105-1,724)	1,006[d] C* (780-1,300)
Phos-Chek D75-F	Soft	>1,700 A	266[e] B (213-327)	279[d] B (216-360)	234 B (191-291)	218[d] B (170-280)
	Hard	>3,600 A	235[e] B (183-287)	218[d] B (170-280)	218[d] B (170-280)	218[d] B (170-280)

[a]LC50 = lethal concentration at which 50% of the sample size experiences lethality. [b]ASTM = American Society for Testing and Materials. Asterisks denote a significant difference ($p<0.05$) in toxicity of test formulations between soft and hard water. Common uppercase letters denote no significant difference ($p<0.05$) among life stages within a test formulation and water quality. [c]dph = days posthatch. [d]No partial kills; 95% confidence interval: lower limit = highest test concentration with 0% mortality, upper limit = lowest test concentration with 100% mortality. [e]Test were started with true sac-fry.

In general, fire retardants currently are not used on National Wildlife Refuges in Alaska unless the fire may spread and threaten a resource designated for fire protection. The fire retardant currently approved for aerially application in Alaska is Fire-Trol LCG-R (Appendix L). According to a study conducted by Gaikowski et al. (1996), Fire-Trol LCG-R is less toxic than Phos-Check D75-F. The 96-hour median lethal concentrations (LC50s) for Fire-Trol LCG-R and Phos-Chek D75-F at various life stages for rainbow trout are displayed in Table 2 .

The recommended field mixtures for Fire-Trol LCG-R and Phos-Chek D75-F are 1 gal/4.5 gal (270,400 mg/L) and 1.20 lb/gal (143,800 mg/L), respectively (Gaikowski et al. 1996). Application at these field concentrations may result in lethal concentrations in aquatic environments; field concentrations can be much higher than acute toxicity values (Table 2) (Gaikowski et al. 1996). For example, one drop of Phos-Chek D75-F would have to be diluted 515- to 660-fold (depending on water hardness) to reach a concentration near the 96-hour LC50 (Gaikowski et al. 1996).

Summary: Fires and Fire Retardants

Currently, fire retardants are not routinely used on KNWR, and because phos-chek readily degrades in the environment, residual impacts from historic fire retardant use are unlikely.

Inholders

Some past, current and future inholders may pose possible contamination threats to the refuge. Inholders are entities who privately own land within the boundaries of a federal preserve, such as a National Wildlife Refuge. This section will examine possible contamination issues posed by inholders.

Some of the items found at the Caribou Island inholding included a 500-pound transformer, improperly stored drums of unknown substances and an extensive uncovered trough containing petroleum products.

Caribou Island Inholding

One inholding of particular concern was the Caribou Island inholding. Some of the items found at this inholding included a 500-pound transformer, improperly stored drums of unknown substances and an extensive uncovered trough containing petroleum products. According to the ADEC, the transformer was not a PCB-containing transformer, and therefore PCBs were never sampled for on the property. In 1991 this site was added to the ADEC contaminated sites database (ADEC spill number 1991230117202), and the ADEC utilized emergency funds for contaminant removal and cleanup to prevent chemicals from entering Skilak Lake.

Native Corporation Inholdings and Other Inholdings

With the passage of the Alaska Native Claims Settlement Act (ANCSA) in 1971 and ANILCA in 1980, Native Corporations acquired thousands of acres of refuge land, including subsurface mineral rights (Figure 12). These lands currently remain within the refuge boundaries. Additionally, some of these native lands border refuge lands designated as Wilderness.

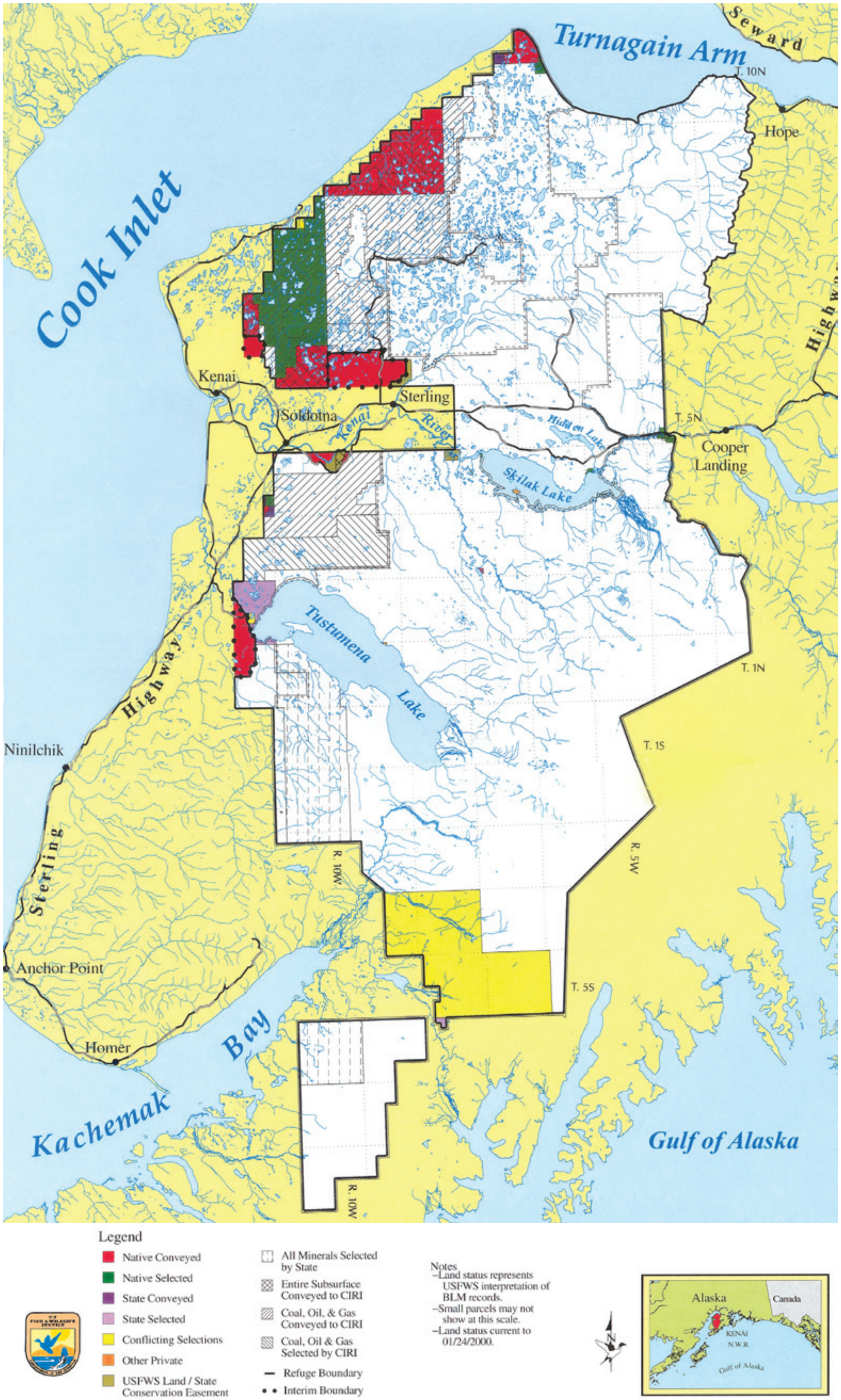
The State of Alaska also has inholdings on the refuge that include subsurface mineral rights. Additionally, there are some other private inholders within the refuge.

Please note that refuge land status has changed several times and likely will continue to change in the future. For the most recent land status, please contact the USFWS Division of Reality in Anchorage, Alaska at (907) 786-3490.

Summary: Inholders

Inholder activities will continue within the refuge boundaries, and it is plausible that contamination events from inholder activities may threaten refuge lands. Development at inholdings likely will impact the refuge, especially if natural resource extraction occurs.

Figure 12. Generalized Land Status of Kenai National Wildlife Refuge.



Graphics by USFWS, Region 7 Division of Realty.

Aircraft Accidents

According to the refuge narratives, from 1948 to 1995 at least 74 aircraft accidents have occurred on the refuge, and this is a conservative estimate. It appears that most of the aircrafts have been removed from the refuge. These crashed aircraft likely pose more of a solid waste issue than a contaminant issue to refuge lands; however, spilled aircraft fuel and lead from unrecovered batteries could be a minor issue.

This Cessna 337 crashed on refuge lands after running out of fuel. USFWS Photo by Robert A. Richey.

Biotic Sources and Physical Transport of Contaminants

Migratory species could be exposed to contaminants outside of the refuge boundaries. When these species return to the refuge, they may be vectors for contaminants, potentially affecting other refuge resources.

Biotic Sources

Anadromous fish and migratory birds are possible biotic sources of contaminants. Because these species are highly mobile, they could be exposed to contaminants outside of the refuge boundaries. When these species return to the refuge, they may be vectors for contaminants and may impose contaminant-related risks to other refuge resources and humans.

A study conducted by Ewald et al. (1998) documented the biotransport of contaminants, such as DDT and PCBs, by a population of sockeye salmon in Copper River, Alaska. The salmon accumulated relatively low levels of contaminants during their ocean life stage and transported contaminants to their freshwater spawning areas. The results of the study suggested that other species, like arctic grayling (*Thymallus arcticus*), may accumulate contaminants that are transported by sockeye salmon into freshwater ecosystems.

Migratory birds may be exposed to an array of potentially toxic chemicals on their wintering grounds in the lower 48 States and in other countries, including chemicals that are banned or no longer used in the United States. During the spring migration, birds may transport these contaminants to their nesting grounds in Alaska. This migratory transport of contaminants provides a potential exposure pathway to other organisms which would otherwise likely not be exposed to these chemicals.

Currently, it is not known if biotic transport is a contaminant pathway affecting refuge resources.

Arctic and sub-arctic environments are especially vulnerable to the long-range air and water transport of environmental contaminants. Some environmental contaminants of particular concern within the Arctic are persistent organic pollutants, such as PCBs, dioxins, DDT, HCH, chlordane, toxaphene, mirex and dieldrin; heavy metals, such as cadmium, mercury, lead; PAHs and radionuclides.

Physical Transport

Environmental contaminants from local and distant sources are subject to short and long range transport. Artic and sub-arctic environments are especially vulnerable to the long-range air and water transport of environmental contaminants because once chemicals reach colder climates, less volatilization occurs. Some environmental contaminants of particular concern within the Arctic are persistent organic pollutants (POPs), such as PCBs, dioxins, dichlorodiphenyltrichloroethane (DDT), hexachlorocyclohexane (HCH), chlordane, toxaphene, mirex and dieldrin; heavy metals, such as cadmium, mercury, lead; polycyclic aromatic hydrocarbons (PAHs) and radionuclides.

There is some evidence that the KNWR may be exposed to contaminants from off-site sources. PCBs (Aroclor 1254 and/or 1260) have been detected in low concentrations in snowshoe hares, shrews, clams, slimy sculpins, rainbow trout and arctic char on KNWR (Ecology and Environment, Inc., 1986). To date, there is no documentation that these aroclors were used on the refuge. The most likely source of these aroclors is atmospheric deposition.

Areas of Concern and Future Sampling Needs

This assessment report was designed to summarize the known and potential contamination issues for KNWR. The large size of the refuge makes it virtually impossible to fully assess all potential contamination issues. This investigation documents the major known contamination events, their sources, and potential future contamination issues including: oil and gas development, pesticide use, FUDS, development near the refuge boundaries, mining, waste disposal, recreational uses, fires and fire retardants, inholders, aircraft accidents, biotic sources and physical transport of contaminants. By compiling this information, a better understanding has been gained about contaminant issues that may impact the KNWR and its resources. As a result of this contaminant assessment, some areas of concern, future sampling needs and potentially contaminated areas have been identified.

One of the most interesting and alarming issues that surfaced during this investigation was the presence of contaminants on the refuge that went unnoticed for decades. This issue is disconcerting, and one cannot help but wonder if other contaminant issues still remain undiscovered.

Area of Concern: Unnoticed Contamination Events

One of the most interesting and alarming issues that surfaced during this investigation was the presence of contaminants on the refuge that went unnoticed for decades. This issue is disconcerting, and one cannot help but wonder if other contaminant issues still remain undiscovered. The dates when some of the major known contamination events occurred and when they were actually discovered are presented in Table 3.

Area of Concern: Oil and Gas Development

To date, most of the spills and contamination events that have occurred on the refuge are related to oil/gas activities. In the future, oil and gas activities likely will remain as the greatest potential sources of spills and contamination events for the refuge. New exploration and associated production activities will create additional sites which will require monitoring. Furthermore, the shutdown of the existing oil/gas fields, Swanson River Field and Beaver Creek Field, will be a major contaminant concern as facilities and sites are taken offline.

Future Sampling Needs and Potentially Contaminated Areas

Many contaminant issues went undetected for extended periods of time at Swanson River Field and Beaver Creek Field. These undiscovered contamination events resulted in costly remediation activities. A well-supported contaminant assessment and monitoring program probably would have detected some of these problems earlier, which likely would have saved time and money. Industry may benefit financially by establishing a proactive contaminant assessment and monitoring program that incorporates sampling for contaminants on a periodic basis. The discovery of extensive PCB contamination at SRF in 1984 highlights the importance of systematic contaminant surveys.

Table 3. Major Known Contamination Events: When They Occurred and When They Were Discovered.

Contamination Event	*Occurred*	*Discovered*
Polychlorinated biphenyl contamination at Swanson River Field	August 30, 1968 (unreported fire at the therminol heater building); January 26, 1972 (compressor plant explosion)	1984
Petroleum hydrocarbons and pentachlorophenol contamination at the Skilak "boneyard"	Served as a repository since 1941	1988
Xylene contamination at the Pipe and Supply Yard in Swanson River Field	Early 1970s	1988
Tank farm spill at Beaver Creek Field	Unknown; leak likely had been occurring for several years	1988
Petroleum hydrocarbon contamination at tank settings/flare stack at Swanson River Field	Unknown	1989-1990
Petroleum hydrocarbon contamination at the electric shop and 243-4 mud disposal well pad at Swanson River Field	Unknown	1989-1990
Pentachlorophenol contamination at the Moose Research Center	1960s	1991
Diesel spill at Beaver Creek Field	Unknown; leak likely had been occurring for several years	1991

The refuge also could greatly benefit from more baseline studies, which assess contaminant levels in soil, sediment, water and biota. A paucity of data exists for establishing contaminant baseline levels on the refuge. Baseline data would be helpful in assessing the impacts from potential contaminant sources on and near the refuge. For example, baseline sampling in areas that are likely to see new activities and an increase in existing activities (like oil/gas development) may aid in management decisions and to assess impacts due to future spills and contamination events. These data also could be used to establish the contaminant contribution from off-refuge sources including atmospheric and biotic transport mechanisms. Ideally, contaminant baseline studies would occur on all of the National Wildlife Refuges in Alaska, followed by periodic trend monitoring.

Several potentially contaminated areas exist on the KNWR. Some of these areas are documented contaminant sites where formal cleanup activities have occurred; however, it may be beneficial to conduct additional sampling at these areas to determine if residual contamination is an issue. Other potentially contaminated areas have not been examined for contaminants. The following areas/species are recommended for future inspection and/or sampling:

1) A contaminant assessment and monitoring program is recommended for Swanson River Field and Beaver Creek Field. Due to the history of undiscovered contamination events (and known contamination events awaiting remediation), sampling at locations throughout these fields may reveal other contamination issues. Some areas may include the following:

   a) PCB excavation, incineration and disposal sites at SRF (page 12).

   b) Locations where fires and explosions have occurred (pages 28-29).

   c) Former locations of PCB-containing transformers at SRF (page 29).

   d) Former locations of mercury manometers at SRF (pages 29-30).

2) Locations where pesticides such as 2,4-D and 2,4,5-T were used; dioxin contamination could be an issue (page 32).

3) Former Army recreational camp at Skilak Lake (page 35).

4) Naptowne Radio Relay Site (pages 35-36).

5) Surprise Creek mining location (pages 44-46).

6) Cooper Creek watershed and the Kenai River downstream from where mining occurred on Cooper Creek (page 47).

7) Anadromous, migratory, and resident species to determine baseline contaminant concentrations and determine if biotic transport of contaminants is a concern (page 59).

Conclusion

Our National Wildlife Refuges do have contaminant issues, even in remote locations like Alaska. It is the responsibility of the USFWS to conserve, protect, and enhance fish and wildlife and their habitats for the continuing benefit of the American people. Utilizing the contaminant assessment process is one way in which the USFWS can ensure that our country's National Wildlife Refuges maintain their environmental health and integrity. The information gathered during the contaminant assessment process allows USFWS personnel to make informed management decisions about contaminant threats to refuge lands and resources.

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