Health Consultation

Evaluation of PCBs Associated with the Former Radio Relay Station Area, Former Fort Morrow, and Other Former Use Areas, Port Heiden, Alaska

SEPTEMBER 18, 2014

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Atlanta, Georgia 30333

Health Consultations: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a request for information about health risks related to a site, a chemical release, or the presence of hazardous material. To prevent or mitigate exposures, a consultation might lead to specific actions, such as restricting use of or replacing water supplies, intensifying environmental sampling, restricting site access, or removing contaminated material.

Consultations might also recommend additional public health actions. These actions might include health surveillance activities to evaluate exposure or trends in adverse health outcomes, biological indicators of exposure studies to assess exposure, and health education for healthcare providers and community members. These additional health actions normally conclude the health consultation process for a site, unless ATSDR obtains additional information which, in the agency's opinion, indicates a need to revise or add to previously issued conclusions.

This health consultation is ATSDR's evaluation of potential exposures to PCB contamination at the Port Heiden radio relay station site. ATSDR is primarily an advisory agency—that means its reports usually identify actions it deems appropriate for others to take, such as U.S. EPA or state regulatory agencies, federal or state public health agencies (including the research or health/community education divisions of ATSDR), military branches and units, and the Native Village of Port Heiden.

Contact ATSDR Toll Free at

1-800-CDC-INFO

or

Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

Evaluation of PCBs Associated with the Former Radio Relay Station Area, Former Fort Morrow, and Other Former Use Areas, Port Heiden, Alaska

Prepared By:

U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Community Health Investigations
Western Branch

Table of Contents

Tables and Figures

List of Abbreviations

ADEC	Alaska Department of Environmental Conservation
AFB	Air Force Base
AMAP	Arctic Monitoring and Assessment Programme
ATSDR	Agency for Toxic Substances and Disease Registry
bgs	below ground surface
BHHRA	Baseline Human Health Risk Assessment
CDC	Centers for Disease Control and Prevention
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CEOS	Civil Engineering and Operations Squadron of the USAF
CES	Civil Engineer Squadron of the USAF
CEL	Cancer Effect Level
DHHS	Department of Health and Human Services (U.S.)
DERP	Defense Environmental Restoration Program
DEW	Distant Early Warning line radar station
DOD	U.S. Department of Defense
dw	dry weight
EPC	Exposure point concentration
FDA	Food and Drug Administration
FCB	Former Composite Building
FFA	Former Facility Area
FSA	Facility Source Area
FUDS	Formerly Used Defense Site
HIs	EPA's Hazard Indexes
IARC	The International Agency for Research on Cancer
IRP	Installation Restoration Program
LOAEL	Lowest Observed Adverse Effect Level
mg/kg	Miligrams per Kilogram (equivalent to ppm for contaminants in soil)
MRL	ATSDR's Minimal Risk Level
NHANES	National Health and Nutrition Examination Survey
NVPH	Native Village of Port Heiden
OC	Organochlorine Compound
ppb	parts per billion
ppm	parts per million
ppt	parts per trillion
PAH	Polycyclic Aromatic Hydrocarbon
PCB	Polychlorinated biphenyl
POL	Petroleum, oil, and lubricants
RfD	EPA's Reference Dose
RI/FS	EPA's Remedial Investigation/Feasibility Study
ROD	EPA's Record of Decision
RRS	Radio relay station
TCDD	tetrachlorodibenzodioxin
TEFs	Toxicity Equivalency Factors
TEQ	Toxic Equivalency
TSCA	Toxic Substances Control Act
USACE	United States Army Corps of Engineers
USAF	United States Air Force
WACS	White Alice Communication System

Summary

PURPOSE	ATSDR recognizes that Port Heiden residents need more information about the possibility of current and future exposures to PCB contaminants in their environment. The community petitioned ATSDR with health and environmental concerns associated with the former radio relay station. Relay stations are known for their use of PCBs as an insulator. Long after the Air Force stopped using the relay station they and the Army Corps of Engineers collected environmental samples. We consolidate and evaluate that data here. The purpose of this Health Consultation is to give community members the information they need to protect their health. Its purpose also is to recommend actions that Defense and other agencies can take where known contamination exists to protect the community's health. To achieve these purposes, ATSDR evaluated the possible ways people could have contacted PCBs from the site; then evaluated the exposure doses using the data collected by Defense; filled in some data gaps using what is provided in literature; and then compared the doses with studies used to evaluate harmful effects.
BACKGROUND	The Port Heiden, Alaska community subsists from the natural foods on and around the Peninsula. The Alaskan waters have PCB contamination from several sources worldwide. Parts of the land in Port Heiden have also been contaminated, including PCBs from a former radio relay station. The radio relay station used generators, transformers, and other equipment that contained PCBs. Some PCBs spilled, leaked or otherwise escaped into the soil in and around the radio relay station. There are several soils sampling investigation that provide information about soil contamination and contamination of plants. It is important to note that Subsistent Alaskan populations are exposed to PCBs which have accumulated in their marine environment due to sources worldwide. This fact makes it essential to reduce other PCB exposures where possible.
OVERVIEW OF THIS HEALTH CONSULTATION	This Health Consultation focuses on possible PCB exposure from direct contact with soils at the site, soils on other parts of the million-acre base, and soils impacted by PCBs from uncertain sources. It also includes exposure to PCBs from eating berries and eating some other foods. It also identifies what foods we know little about and the periods of time in

	the past for which there is little information to evaluate exposures. The most important advice to the community regarding site-specific PCB exposure is to not collect berries and plants from the areas where contamination signs are posted; to continue to limit time spent in the areas marked for cleanup until it's completed; and to increase fruit and vegetable intake to help reduce risks of PCB exposure. Summarized conclusions for specific areas and time periods follow; more detailed information on these areas is provided in the report.
CONCLUSION 1	Before 1990: We don't have enough data to evaluate pre-1990 PCB exposure at the Port Heiden radio relay station site.
BASIS FOR CONCLUSION 1	There is no information to determine the concentration of PCBs in the soils removed from the site prior to that date or if those soils were reasonably accessible.
NEXT STEPS FOR CONCLUSION 1	ATSDR provided dose estimates for various measurements that were made after 1990. These could be adjusted should pre-1990 PCB data become available.
CONCLUSION 2	Between 1990 and 2014: With the infrequent exposure reported by the community, we don't anticipate noncancerous or cancerous health effects from exposure to PCBs in the radio relay station soil.
BASIS FOR CONCLUSION 2	Because of the removals of soil and oils prior to 1990, exposure became less likely. PCB doses indicate a health concern only if people contacted some "hot spot" areas on the Relay Station on a daily basis. Community members indicated that they accessed the areas primarily for viewing wild game during this time and soil exposure might occur a few times in a season. Thus the highest daily dose from soil would not occur more than a few times in a year.

NEXT STEPS FOR CONCLUSION 2	Known PCB hotspots in soil are covered or continue to be cleaned up. Since subsistent Alaskans are exposed to PCBs from the marine environment due to sources worldwide and since some additional PCB exposure could have occurred at Port Heiden, we recommend reducing PCB risk where possible. Therefore residents can help reduce some PCB risk by eating more fruits and vegetables that are grown in places other than the hot spots.
CONCLUSION 3	Crowberries growing near the radio relay station antenna pads contained PCBs at levels too low to pose a hazard themselves, but are an avoidable source of PCBs.
BASIS FOR CONCLUSION 3	Crowberries growing near the radio relay station antenna pads contained Aroclor 1260 concentrations close to the FDA limit for commercially sold infant or junior foods. We estimated that the potential doses for children were above the levels of ATSDR's intermediate and chronic MRLs and below the lowest effect level for animals. Although we do not view eating the crowberries alone as posing any PCB-related health effects, there is a potential for additional PCB exposures from other foods.
NEXT STEPS FOR CONCLUSION 3	Avoid plants grown near the radio relay station. Signs posted in the radio relay station area warn against eating any edible vegetation growing there. However, because fruits and vegetables have been shown to reduce PCB risks, eating fresh fruits and vegetables grown elsewhere is encouraged.
CONCLUSION 4	We anticipate no PCB-related adverse health effects from eating small animals harvested at the radio relay station site at the current time.
BASIS FOR CONCLUSION 4	The small animal doses were much lower than those for soil and berry ingestion.
NEXT STEPS FOR CONCLUSION 4	None
CONCLUSION 5	Access to the Foundation Cover Soils/Pad Grid 1 is not likely and is not expected to be frequent enough to result in harmful exposures.
BASIS FOR CONCLUSION 5	Several soil PCB results from the Foundation Cover Soils/Pad Grid 1 area of the radio relay station site exceeded 1,000mg/kg. They had not

	been removed by December 2013, nor were there reports of their removal by June 2014. Although the areas have been accessed, they are very unlikely to have been accessed with any frequency. Dose calculations indicate a hazard only with very frequent access; however, hunters and others visiting the elevated lands were not likely to access the hotspots with sufficient frequency to result in adverse health effects. A fence has been placed around all hot spot areas and tarps are on the hot spot soil piles, preventing potential access.
NEXT STEPS FOR CONCLUSION 5	The planned removal of the covered soils will prevent harmful exposures in the future and further reduce the migration of PCBs to the vegetation or migration elsewhere.
CONCLUSION 6	Recently and Currently: PCB concentrations detected in roadway samples taken from the airport to the radio relay station area show that people who use that roadway will not be exposed to harmful levels of dust-borne PCB contamination.
BASIS FOR CONCLUSION 6	Although the roadway is more frequently accessed than the former relay station, the samples averaged much less than the soils at the relay station. In the 2013 the roadway hotspots were covered with tarps which should further reduce the chance accidental exposures.
NEXT STEPS FOR CONCLUSION 6	These soils are planned for removal. There is trace levels of PCBs found adjacent to these hotspots; these are thought to be from an old Army power plant and will be investigated further.
CONCLUSION 7	We cannot assess PCB concentration in the marine food chain exposure pathway. PCB data are unavailable for clams and walruses—subsistence food sources for residents in the Bristol Bay area near Port Heiden.
BASIS FOR CONCLUSION 7	No local data has been collected. While the relay-station PCBs appeared to remain in the hot-spot areas, other less concentrated hotspots were found on roads, and still other PCBs from uncertain sources were also found in areas closer to the community. Some wastes, not expected to contain PCBs, were disposed into borrow pits and selected sites, but no data is available to ensure that those areas are PCB-free.
NEXT STEPS FOR CONCLUSION 7	There is no current plan to sample these local species. Furthermore, investigations of potential burial sites closer to the marine environment are progressing slowly due to the uncertainty of a responsible party. We recommend sampling the local species to ensure that there is no added impact from local PCB sources.

	We have provided references of PCB measurements made in other studies in the greater regional waters. While PCB contamination in marine life is caused by many sources, the amount of PCBs in the local species remains unknown.
FOR MORE INFORMATION	For questions or comments, call ATSDR toll-free at 1-800-CDC-INFO and ask for information on the Pacific Coast Pipeline site.

Purpose and Statement of Issues

This health consultation is one of a series of focused health consultations that evaluate community concerns about past military activities in the Port Heiden area. We address here issues related to polychlorinated biphenyls (PCBs) at and near a former U.S. Air Force (we'll refer to "U.S. Air Force" as "USAF") radio relay station. The USAF built the radio relay station in Port Heiden as well as other places in Alaska because of their great distances from the continental US. While the radio relay station was in operation, the USAF used generators, transformers, and other equipment that contained PCBs. Some PCBs spilled, leaked or otherwise escaped into the soil in and around the radio relay station. After the USAF abandoned the radio relay station in the 1970s, the barracks, the radio station, the antennae, and other equipment and buildings were demolished and buried in landfills [ADEC 2008]. Most if not all of the transformers were taken away from Port Heiden, but other PCB-containing materials were not. Some of the building materials were contaminated with PCBs. PCBs leaked or spilled from some buried equipment. Thus the PCBs that remained in the soil under and near the former radio relay station, and the PCBs that were buried with the disposed equipment found their way into soil in and near the radio relay station and the landfills. Some PCB-contamination occurred on the road between the radio relay station area and the port facilities near the old village of Port Heiden (Meshik).

Most of the PCB soil contamination occurred on areas of Port Heiden that were operating U.S. government facilities.[1] And that contamination could enter the natural food supplies on which Port Heiden residents depend. In this health consultation, we focus on PCBs in soil in and near the former USAF radio relay station area[2] at Port Heiden, Alaska, but include other areas where PCBs have been found.

We learned that from 1981 to 1986, the Air Force 5099th Civil Engineering and Operations Squadron removed PCB fluids, waste, oil, and PCB-contaminated soil from the radio relay station site. But USAF [1994] stated that "No USAF records are available to indicate how the soils were identified, what PCB concentrations were removed, or the method of disposal upon reaching Elmendorf [Elmendorf Air Force Base, Anchorage, AK]." Still, we did locate other, later radio relay station disposal and test data. From an analysis of those data we found that dose estimates based on ingestion of PCBs in site soil were such that for current Port Heiden residents, adverse health effects were unlikely.

[1] Both the Army and the USAF are responsible for the FUDS and radio relay station cleanup. The USAF is responsible for cleanup related to the radio relay station. The Corps, under the Formerly Used Defense Sites (FUDS) program, is responsible for environmental cleanup associated with past military activities on land that was transferred out of the DOD control before 1986.

[2] The site's official name is the White Alice Communication System/Radio Relay Station (WACS/RRS) site. We refer to it in this health consultation as the radio relay station site.

But because of the data gaps cited above we can’t adequately evaluate total waste exposures at the site. During 1990−1992, well after the early-1980s demolitions, the USAF’s 11th Air Control Wing, 11th Civil Engineering Operations Squadron conducted further site investigations and documented its contamination-removal activities. The Alaska Department of Environmental Conservation collected and summarized the USAF records [ADEC 2008]. We obtained those data and records from ADEC and USAF and used them in our evaluation of the radio relay site.

But with regard to the absence of any early records, we note an important fact. This Port Heiden site is not a CERCLA Superfund Site. As such, material could be and was removed before the site was characterized (i.e., before determining and documenting the nature and extent of any contamination). It was not until recent times that the site began following CERCLA guidance for cleanup.

ADEC [2008] also discusses soil samples collected after completion of much of the remediation and discusses PCBs in other media, such as groundwater, berries, and small mammals. But no data are available on PCBs in subsistence foods, such as cockles or marine mammals in Bristol Bay near the former village of Meshik (old Port Heiden). Due to PCB exposure in multiple pathways through land ecosystems (e.g., water, air, soil, edible plants and animals) and the potential for additional exposure through the marine ecosystem, further characterization is desirable for these foods and for reduction of PCB body burdens in Port Heiden residents.

Background

The Port Heiden area is near the mouth of Meshik River along the northern coast of the Alaska Peninsula, adjacent to Bristol Bay and the Bering Sea. The Port Heiden area is approximately 400 miles southwest of Anchorage (Figure 1). The area comprises two former military installations: Fort Morrow, which is now a FUDS (formerly used defense site) and the Port Heiden radio relay station, converted from a White Alice Communication System [ATSDR 2010; ADEC 2008]. The radio relay station site is within Fort Morrow.

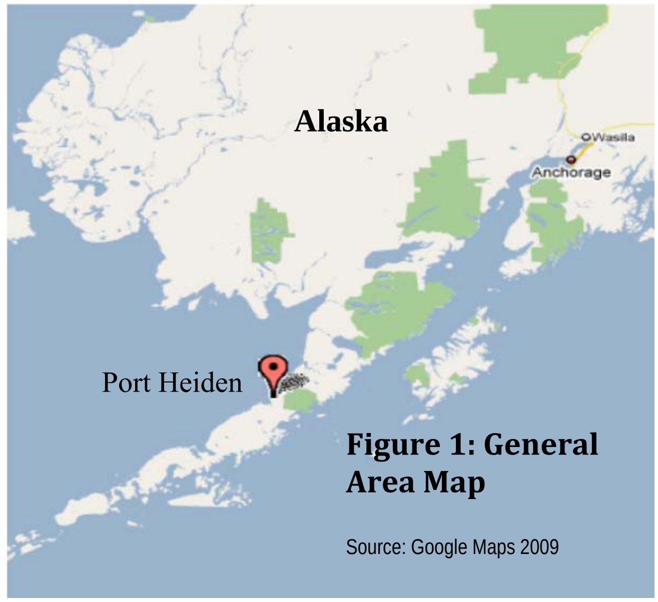


Figure 1: General Area Map

Source: Google Maps 2009

Fort Morrow was a WWII Army Base. Constructed in 1942, Fort Morrow's airfield and protective garrison provided air defense for Alaska and for the naval base at Dutch Harbor. Following WWII, the War Department (later renamed the Department of Defense) decommissioned Fort Morrow.

In the 1950s, the Air Force acquired 172 acres of former Fort Morrow land and constructed a communication station approximately 6 miles north of the village of Meshik and about 2 miles from the current city of Port Heiden [ANA; ATSDR 2005; Roth 2014]. The Air Force operated the communications station until 1969 when it was converted to a radio relay station. The relay station was active as a Distant Early Warning (DEW) line radar station into the late 1970s; the relay station then became obsolete and abandoned [ADEC 2008a; USACE 1987]. In 1990, the USACE Alaska District as part of the Defense Environmental Restoration Program, contracted for the demolition, restoration, and remediation of the Radio Relay Station, Fort Morrow buildings, Quonset huts, structures, towers, tanks, drums, and other miscellaneous debris. Demolition debris was placed into two permitted one time use mono-fills identified as Landfill A and Landfill B. Borrow pits and selected sites were also used by the Air Force for disposal of wastes [ADEC 1985].. As of the date of this health consultation, cleanup continues.

The Village of Meshik (old Village of Port Heiden) was a traditional fishing village west of the radio relay station site, along the Meshik River and shorelines (Figure 2). After coastal erosion and wave action washed away much of the old village, residents moved to higher ground south of the Port Heiden airport and south of the Port Heiden radio relay station site (Figure 2). Incorporated in 1972 and within the boundaries of the Port Heiden Formerly Used Defense Site,

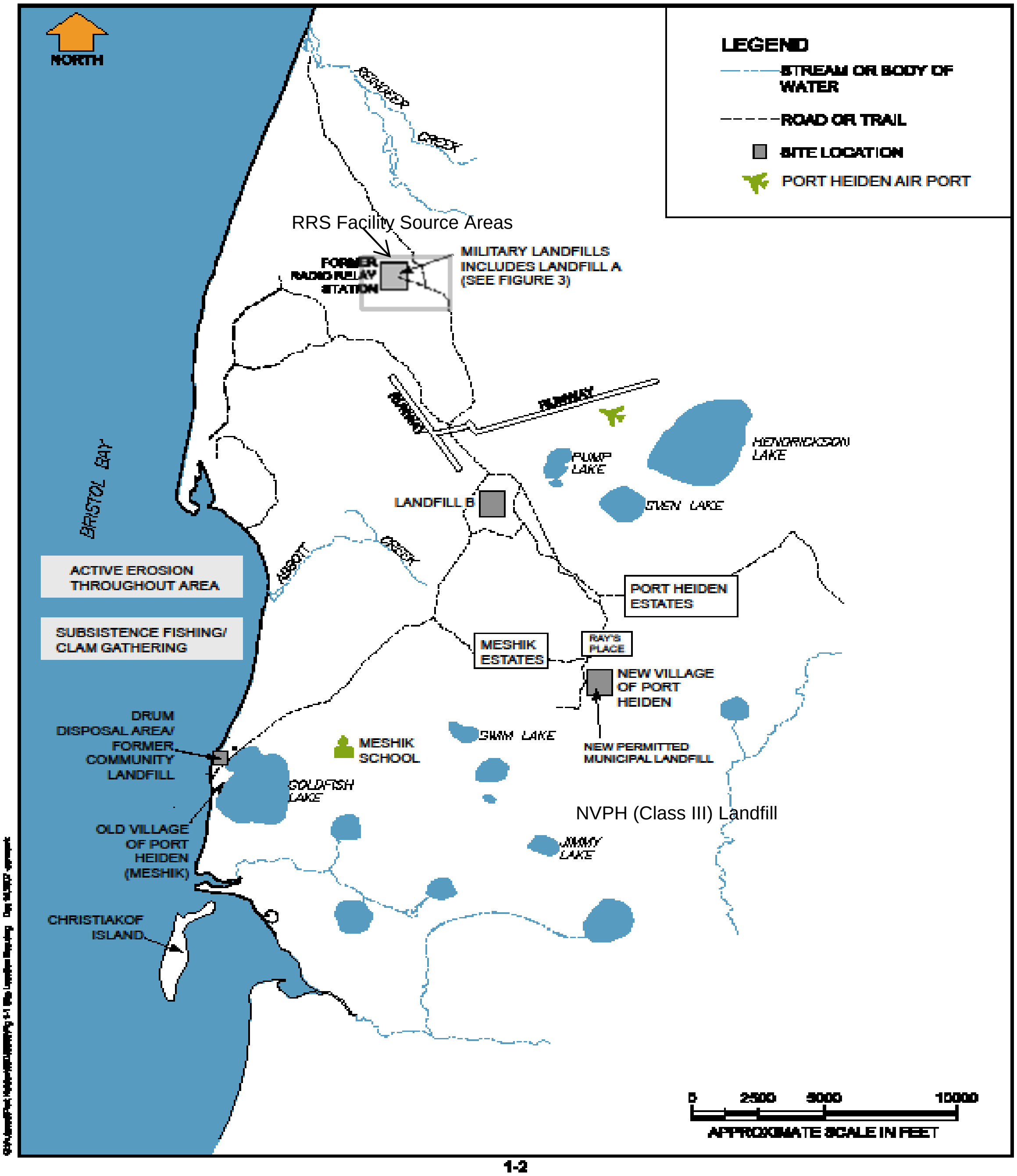
the community currently referred to as the “Village of Port Heiden” is
sometimes also referred to as the “new” Village of Port Heiden to distinguish it from the original Meshik settlement, also known as the “old” Village of Port Heiden [ADEC 2003].

Demographics

Until the 1960s to early 1970s, the original Meshik settlement was a traditional coastal fishing village. The village comprised a community building, a school, a small store, and 14 residences. By 1977, the Meshik settlement (i.e., the “old” Village of Port Heiden) had a population of 85 persons [USACE 1979]. Around 1994, that number had shrunk to 10 [USAF 1994] after most residents moved inland to the “new” village of Port Heiden (Figure 2). By 2010, the U.S. Census Bureau identified 102 persons as residents of the “new” village of Port Heiden [Anderson 2010a; U.S. Census Bureau].

The Port Heiden community includes a federally recognized tribe. In fact, over three-quarters of the population is Alaska Native or part Native. The community follows a commercial fishing and subsistence lifestyle. For Port Heiden community members, subsistence harvests of salmon and other fish, marine mammals, game, birds, plants, and berries are important dietary staples [ATSDR 2010; USAF 1998].

Figure 2. Port Heiden Area Map



PCBs in the Port Heiden Area

General PCB Information

Polychlorinated biphenyls (PCBs) are manufactured organic chemicals. PCBs aren't found in the natural environment. PCBs have insulating and flame retardant properties. In water they're generally inert (i.e., chemically stable) and relatively insoluble (i.e., they dissolve only with difficulty). But in fats, they're highly soluble.

PCBs are chemical compounds with chlorine atoms attached to the biphenyl molecule. They enter the environment as mixtures of individual components known as congeners. The 209 possible congeners are numbered 1–209. The heavier congeners contain more chlorine and are assigned higher numbers. Each congener has different properties (e.g., solubility, vapor pressure, toxicity).

In 1977, the United States banned PCBs for commercial use. Accumulated evidence showed that PCBs could build up in the environment and make people sick. Residual PCBs remain in products such as old fluorescent lighting fixtures, electrical devices or appliances containing PCB capacitors made before the PCB ban, as well as old microscope oil and old hydraulic oil [ATSDR 2000a]. Most PCBs commercially produced in the United States were standard mixtures marketed under the trade name Aroclor. Each Aroclor was a mixture of various PCB congeners. Identification of specific congeners can more accurately assess potential adverse health effects and more easily identify PCB contamination sources. The lightly chlorinated PCB mixtures, such as Aroclors 1221–1248, were clear oils, whereas the more highly chlorinated mixtures, such as Aroclor 1260, were viscous resins [Schantz 1996]. Aroclor 1260 is a light yellow, sticky resin that's highly soluble in organic solvents [ATSDR 2000a; Bedard and May 1996; Schultz 1989]. Twelve dioxin-like congeners are associated with cancer [ATSDR 2000a; Rushneck et al. 2004].

When released into the environment, Aroclors weather, which alters their physical and chemical composition. Weathering can complicate matching an environmental sample with an Aroclor pattern, leading to difficulties in PCB source identification. Once in the environment, PCBs do not easily breakdown, but some can transfer between air, water, and soil under the right conditions. PCBs usually stick to soil and sediment; rainwater usually will not carry them deeply into the soil. Lighter PCBs leave the soil by evaporation. Small PCB amounts are found in almost all outdoor and indoor air, soil, sediments, surface water, and animals [ATSDR 2000a].

Food-chain PCB exposures, discussed in detail later, are of particular interest. People are exposed to PCBs primarily by eating contaminated foods, particularly fish, meat, poultry, and dairy products [ATSDR 2000a; Theelan et al. 1993]. Generally, most nonaquatic food, air, water, and soil are considered less important PCB-exposure sources. Dermal and inhalation are also considered minor exposure routes [DeCaprio 2005]. And although people can be exposed to PCBs in air, water, soil, or sediments, chronic, low dose exposure through diet is the main concern for the general population, especially in foods of animal origin [Goni et al. 2007].

Human Health Effects of PCB Exposure

Both PCBs and their breakdown products have significant effects on human health [NIEHS 2009]. PCBs might enter the lipid portion of the blood and fatty tissue. Due to their high prevalence and persistence, PCBs 138, 153, and 180 are the most consistently detected congeners found in human tissue [ATSDR 2000a]. These congener distributions in humans do not resemble any Aroclor [Cogliano 1998]. Using evidence of carcinogenicity from experimental animal studies, the scientific and medical communities generally agree that PCBs could cause cancer in humans [NPT 2011]. U.S. EPA classifies PCBs as probable human carcinogens. The International Agency of Research on Cancer (IARC) rates PCBs as probably carcinogenic to humans. We know that PCBs have significant toxic effects on the immune, reproductive, nervous, and endocrine systems of animals [ATSDR 2000a]. Currently ATSDR's Toxicological Profile for PCBs doesn't list any adverse effect level for humans [ATSDR 2000a].

Studies of wildlife communities first prompted concerns about the health effects of PCB exposure; the studies showed reproductive, developmental, endocrine, immunological, and carcinogenic effects [ATSDR 2000a]. If PCBs get into a person's body, some of the PCBs might be changed by the body (metabolized) into other related chemicals called metabolites. As a person ages, blood PCB levels tend to increase. Some PCB metabolites have the potential to be as harmful as the PCBs to which the person was originally exposed. While some of the metabolites might take just a few days leave the body in the feces, others might remain in the body's fatty tissues for months. Unchanged PCBs might also remain in the body for years, mainly in the fat and liver. Smaller PCB amounts can be found in other organs as well. PCBs collect in milk fat and can enter the bodies of infants through breast-feeding [ATSDR 2000a]. But amounts that cause serious health problems for some people might have no effect on others. Factors such as diet, genes, lifestyle, preexisting illness, or exposure to other chemicals can influence whether PCBs can cause people to get sick. In fact, little is really known about the long-term health effects of PCBs in humans.

The health effects of environmental mixtures of PCBs are difficult toevaluate. Most of the information in ATSDR's *Toxicological Profile for Polychlorinated Biphenyls (update)* and the Addendum to that toxicological profile is about seven types of PCB mixtures (i.e., Aroclors) that were formerly produced in the United States [ATSDR 2000a; ATSDR 2011]. One such Aroclor is identified at Port Heiden. The profile includes cases in which people were exposed to PCB oils and had swelling of the upper eyelids, numbness in the arms or legs, weakness, discoloring of the nails and the skin, muscle spasms, chronic bronchitis, and problems with the nervous system and thyroid metabolism. Recent studies have reported effects on bone mineral density and association with diabetes in adults [ATSDR 2011]. Other studies have identified that increased fruit and vegetable intake can reduce the probability of polychlorinated biphenyl-associated risk for diabetes [Hofe et al 2014]. Neurobehavioral, immunological, and developmental deficits were reported in newborn monkeys exposed to PCBs *in utero* and who consumed (0.0075 mg/kg/day) PCBs in breast milk [ATSDR 2000a]. And it's likely that the health risks associated with PCB exposure increase with continued exposure over a lifetime. Less is known about lower environmental exposures, except for those studies addressed below. See Appendix F and a glossary of the specific health terms in Appendix G.

Child Health and other Sensitive Population Considerations

Children

A variety of pathways might expose children to PCBs. Lactation appears to be the main source of PCB intake, given that breast milk contains relatively high PCB concentrations [Fernandez et al. 2008]. Mothers can pass PCBs to children not only through breast milk, but through umbilical cord blood as well. Babies whose mothers eat large amounts of highly contaminated fish are more likely to lose weight and have shorter attention spans than babies whose mothers do not eat fish [Jacobson et al. 1990]. PCB-exposed children tend to do poorly in intellectual functioning and other developmental skills, such as attention span and developmental tests [Jacobson et al. 1990a and b, 1996]. Chronic PCB exposure, particularly through dioxin-like congeners, induces dermal alterations in infants. While the dioxin-like congeners are not yet identified at Port Heiden, congener analysis is lacking. Exposure to PCBs has been positively correlated with neurodevelopmental problems in children, including impaired learning and memory, decreased IQ scores, decreased neuromuscular function, and lower reading comprehension [Kim et al. 2009]. Recent studies have reported possible impaired immunologic development in unborn children [ATSDR 2011]. And as noted, PCBs are a suspected human carcinogen. Thus early-life exposures to PCBs require special consideration [Cogliano 1998].

Those unique vulnerabilities of infants and children also require special consideration in communities whose water, food, soil or air are contaminated. The potential for exposure and subsequent adverse health effects often increase for younger children as opposed to older children or adults. Children are susceptible to developmental toxicity that can occur at levels much lower than those causing other types of toxicity. In this health consultation, therefore, we added a calculation of potential dose to an infant taking in milk from a subsistent mother with frequent access to so-called hot spot areas (i.e., areas with concentrated PCB contamination).

Older Persons

Studies of PCB-exposed communities indicate increased serum PCB levels with increasing age [Orloff et al. 2003; ATSDR 2001b; Nichols et al. 2007]. A community in Anniston, Alabama evaluated for PCB exposure because of contamination in sediments and residential soil from a chemical company [Orloff et al. 2003] showed blood PCB concentrations correlated strongly with age and length of residency in the neighborhood. Residents of a Pacific fishing community in Tanapag Village on the island of Saipan tended to have slightly increased serum PCB levels with increasing age [ATSDR 2001b].

Blood PCB levels can tend to increase with age. The Centers for Disease Control and Prevention (CDC) analyzed data from the National Health and Nutrition Examination Survey (NHANES) 2001−2002 sampling cycle to identify age-specific reference ranges for measured congeners on a lipid-adjusted (serum) basis [Nichols et al. 2007]. These data demonstrated strong age-related trends, with older persons displaying higher concentrations of most congeners and of summed PCB congeners.[3]

NCEH, on the other hand, studied people living in five Aleutian and Pribilof Villages over a 15-year period before 1999 [NCEH 2003]. This study revealed decreasing PCB trends, especially a 30%–40% decrease in those whose diet consisted mainly of fish and marine mammals. Another study was conducted on St. Lawrence Island about 10 years ago [Carpenter and Miller 2011]. The exposure investigation panel determined that because of similar decreases in the previous 10 to 15 years, serum PCB data probably were not a good comparison group for current exposure [ATSDR 2012)].

More information on PCB studies is provided in Appendix D, Studies of Other Communities Exposed to PCBs.

Obese Persons

Because PCBs are lipophilic (i.e., tend to accumulate in the fat), people with higher body fat could store more PCBs and have an increased risk of adverse health effects [Cok and Satiroglu 2004]. Obesity also predisposes to cardiovascular disease. Obesity's effect on PCB toxicity is an emerging research area [NIEHS 2009a].

[3] With regard to the NHANES National Report of Human Exposure to Environmental Chemicals, a panel of exposure investigation scientists determined that because of important differences in diet between native Alaskans and mainland U.S. residents, the report did not provide a valid PCB-exposure level comparison with the Port Heiden population [ATSDR 2012].

Site Workers

Workers who helped to cleaned up debris and soil at the radio relay site were likely to have been exposed to site contaminants. PCB testing of these workers could help to evaluate PCB exposures to them and others.

PCB occupational blood sampling results for village workers

Reports and data are needed on PCB blood sampling of villagers hired by Air Force contractors and executed by the USACE (Weston Solutions or subcontractor LLC). ATSDR considers this information an important data gap for this health consultation. In 2009, blood was drawn for the first group of village workers. Whether the blood samples were analyzed is unclear, but neither the clinic nor the subjects received any test results, and no follow up blood was drawn. In 2010, a second group of workers (some of whom were in the first group) had their blood tested for PCBs and results were provided to the patients [Personal communication, Scott Anderson, Tribal Environmental Office, Native Village of Port Heiden, August 18, 2010]. ATSDR made requests to the Air Force for the results of the blood tests and none were provided [Personal communication, Patrick Roth, USACE, November 8-10, 2010].

While the results of the blood analysis give a complete picture of a person's exposure to PCBs in their environment, it often cannot be used to discern exposure from a single source. In some cases, highly exposed workers do show a pattern [ATSDR 2000; ATSDR 2011]. However, we expect that Port Heiden residents have elevated levels that are not specific to any Aroclor as do many Native Alaskans who consume large fish and marine mammals which contain PCB congeners with long half-lives. Nevertheless, the results of the workers could provide one more clue about exposures that can be compared with various populations discussed later.

PCBs in the Former Facility Area

Several activities might have generated PCBs or might have been potential PCB sources at the Former Facility Area.[4] These areas are described each more thoroughly later. Transformers, capacitors, and switches, some of which contained PCBs, regulated electrical current [USAF 1994]. USAF activities included PCBs to insulate liquids used in heat recovery and circulation systems, which might have contained antifreeze or PCBs.

[4] The Former Facility Area (sometimes referred to as FFA) is that part of the FUDS where the Army and the USAF constructed and installed barracks, radio stations, landfills, roads, and other buildings and equipment. The Former Facility Area comprises more acreage than does the immediate radio relay station area. Compare Figures 2, 3 and 4. The radio relay station site is, however, within and is a part of the Former Facility Area, as are a number of other buildings and installations. For simplicity, in this health consultation we refer to the entire area under investigation as the radio relay station site.

PCB-containing items at the radio relay site included transformers, capacitors, drums of PCB fluids and wastes, and drums of contaminated soil. Ten to 15 transformers with 500−1000 gallon capacity were used at the site over a 20-year period (1958 to 1978), with estimated spills of 200 gallons [USAF 1994; 1996]. Copper pipe, which could have been scavenged from the site, was found to contain PCB scaling. During removals and remediation, contractors removed PCB-contaminated soil from the radio relay site. See Removals and Investigations, below.

USAF contractors used recycled oils to suppress dust, especially on roads. The recycled oils might have contained PCBs and solvents [USAF 1994; 1996; North Wind 2012]. The road system provides transportation routes for subsistence and recreational activities such as hunting, fishing, and berry gathering [ADEC 2008(a)]. In 2004, at the beginning of the remedial investigation, PCB wipe (also referred to as swipe) samples were collected from floors and steering wheels of crew vehicles and from entryways to crew residences and the project office [USAF 2006]. No PCBs were detected in these samples [USAF 2006].

The USAF used borrow (gravel) sites, associated with the existing roads and the airport, for disposal of WACS site wastes and material**.** PCBs could be spread or tracked to residential areas from walking or driving on roads or from PCB oiling areas. *We recommended PCB testing of these borrow sites and transportation routes.* Roads have been tested, PCBs discovered, and remedial action is underway since 2011.

During the Remedial Investigation Feasibility Study (RI/FS) process at the radio relay site, PCB soil analyses included Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260. In samples sent for laboratory analyses, however, Aroclor 1260 was the only Aroclor from this list detected in soils (Aroclor 1242 and 1260 were reported in field testing data in the RI/FS 2004). Therefore, PCB sampling results are reported as Aroclor 1260. Congener-specific analyses were not conducted on environmental samples.

Removals and Investigations

Overview

Table 1 contains a chronological history of removal and investigation activities. Beginning in the 1980s, both the USAF and Army Corps of Engineers (USACE) removed material and investigated the Port Heiden radio relay station site.

Clean-up Levels and Remedies

The lead regulatory agency for the Port Heiden radio relay station is the Alaska Department of Environmental Conservation (ADEC). The lead cleanup agency is the USAF [ADEC 2008c]. In

1991, ADEC approved a final cleanup goal of 25 mg/kg (ppm) for PCB
compounds in soil. This goal was later revised. For unrestricted land use, ADEC's PCB target cleanup levels were 1 mg/kg total PCBs or less within the upper 10 inches of the surface soil, and 10 mg/kg or less within the subsurface soil. In the future, the primary use of land in the vicinity of the radio relay station is anticipated as residential [USAF 2009, USAF 2010]. U.S. EPA's agreed-on PCB soil cleanup level for unrestricted use is also 1 mg/kg (ppm) for both surface and subsurface soils [ADEC 2008c]. No amount of PCB exposure is considered beneficial or even benign, so all levels pose some theoretical risk. Still, levels below 1 mg/kg result in a low theoretical risk. See PCB Results in the Radio Relay Station Investigation Areas. Appendix A contains specific dose estimates.

Table 1. Removal and Investigation Activities at Port Heiden Radio Relay Station Site

Date	*DOD Work Conducted by or for:*	*Activity*
1981-1986	Air Force 5099th Civil Engineering and Operations Squadron (CEOS)	Removed hazardous material (including transformers, capacitors, PCB fluids and contaminated material, and PCB oil) and soil impacted by PCB contamination
1986-1988	United States Army Corps of Engineers (USACE)	Conducted site investigations and prepared bid documents for the complete demolition and restoration of the site
1990-1992	USACE and contractors	Demolition of the site and removal of hazardous wastes including PCB-impacted soil
1995	Air Force 611th Civil Engineer Squadron (611 CES) *	Conducted a Preliminary Assessment and Site Inspection (PA/SI) including the collection of soil samples
2000	611 CES	Collected soil samples at site previously identified for further investigation
2003	USACE	Sampled private drinking water wells in the community of Port Heiden (under the Native American Lands Environmental Mitigation Program)
2004	611 CES	Initiated the Remedial Investigation/Feasibility Study (RI/FS) process to identify any remaining contamination and evaluate risks
2005	611 CES	RI/FS finalized for work performed on 18 sites from May through September 2004. Data collected during the field investigation delineates the nature and extent of contamination
2007	611 CES	Awarded a performance–based contract for cleanup of sites. It included the Proposed Plan, Record of Decision and implementation of remedial actions
2008	611 CES	Amendment to RI/FS: inclusion of soil washing
2008	611 CES	Revised Feasibility Study
2009	USAF including 611 CES	ROD selected and then revised for the Port Heiden radio relay station. Removal of PCB contaminated soil from the FFA.
2010	611 CES	Continued removal of PCB contaminated soil from the FFA.
2011	611 CES	Remediation of PCBs on the road from the airport to the radio relay station has been underway since 2011
2012	USACE	Began investigations for the larger Fort Morrow Site

Adapted from February 2008 Summary by ADEC Contaminated Sites Program [ADEC 2008] and RI/FS [USAF 2006, Table 2-1].

Note: The Air Force 5099th Civil Engineering and Operations Squadron (CEOS) was later renamed the Air Force 611th Civil Engineer Squadron (611 CES).

PCB Results in the Former Facility Area

Source areas investigated at the Former Facility Area include six Installation Restoration Programs:

1. OT001—Former composite building and antenna arrays
2. WP002—Black Lagoon
3. WP003—Gray Lagoon
4. SS004—Septic Tank and Outfall
5. LF07—Radio Relay Station Landfill
6. LF08—Debris Burial Sites.

The source areas were further divided into 15 sites, all of which were investigated in 2004 [USAF 2006, Table 1-1].

For this health consultation, we rearranged these Installation Restoration Programs into Areas 1 through 4]:

- Area 1- FFA Pad: Composite Building & Radio Relay Station Area
- Area 2- Radio Relay Station (North) Landfill (LF007)
- Area 3- Black Lagoon Outfall and Pipeline, Septic Tank, and Septic System Pipeline
- Area 4- Septic System Outfall

We've used these area designations for organizational purposes and for ease of applying U.S. EPA conclusions concerning human health risk assessment. Figure 3 shows investigation areas in the entire Former Facility Area. Our areas encompass the largest number of investigation areas within the original Fort Morrow boundaries. Other source areas are scattered across other portions of the site.

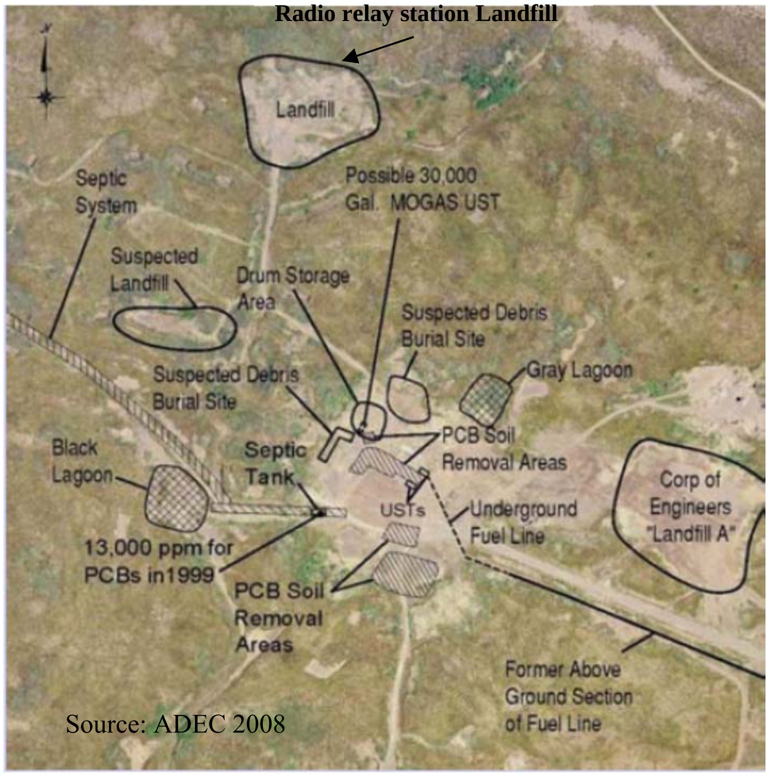
Multiple areas within the FFA Pad contain Aroclor 1260 in soil. Figure 4 shows some of the locations where PCBs in soil have exceeded 1 mg/kg. Although not part of the FFA, PCBs were reported at 25 mg/kg near the Village of Meshik [ADEC 2008a]. PCBs were also reported in soil as high as 30.8 mg/kg on the roadway from the radio relay station to the NVPH (Class III) Landfill [North Wind 2012]

The Air Force 611 Civil Engineer Squadron (611 CES) provides online access to its Air Force Port Heiden radio relay station documents at http://www.adminrec.com/PACAF.asp?Location=Alaska. The data summarized in this health consultation are in these reports. More information was obtained from the ADEC Contaminated Sites Database at http://www.dec.state.ak.us/SPAR/CSP/db_search.htm [ADEC 2008 (a)-(g)]. Site information and data can also be found in the Remedial Investigation/Feasibility Study

(RI/FS) [USAF 2006]. A chronological overview has previously been provided (Table 1 and Overview).

Area 1–FFA Pad: Composite Building/Radio relay station Area

Figure 3. Former Facility Area



Overview

The former facility gravel pad area includes the former composite building, former White Alice Communication System, the radio relay station, the drum storage area, suspected debris burial sites, and former underground storage tanks (Figure 3).

The communication station contained four antennae and feedhorns, a main composite building (a 2-story concrete building with a 5-story tower), and other support structures and systems, including a fresh water storage tank, two buried fuel tanks, two small concrete buildings, and a septic system.

The entire Port Heiden radio relay station area comprised three main subareas: the area near the radar facilities, the marine terminal area on the coast near the old town site of Meshik, and the former pipeline corridor, which connected the radio relay station with the marine terminal area. The USAF still owns a portion of the radio relay station site; the state or the Alaska Peninsula Corporation owns the remaining land (ANA and ATSDR 2005).

Area 1 Contamination

In 1981, USAF removed PCB-contaminated transformers, capacitors, unknown fluids, waste oil barrels, assorted oil-based paints, toluene liquid, and assorted oil-based paints for shipment to Elmendorf Air Force Base. In 1984, USAF shipped transformer oil containing PCBs, 372 drums of PCB-contaminated soil, and other wastes from the WACS site. Although these wastes were sent to Elmendorf AFB, Anchorage, Alaska, their final disposition is unknown [USAF 1996, 2006]. The USAF received waste-disposal permits for cleanup at Port Heiden in 1984, *but we've* *found no records about the contents or location of the debris buried at Port Heiden during the 1984 effort* [ADEC 2008(c)].

In 1985 and 1986, PCB-contaminated soils were excavated and removed from [USAF 1996]:

- IRP site OT001: the FCB,
- White Alice Arrays,
- Diamond Area,
- White Alice Arrays Burial Site-1 (BS-1) and
- Fuel USTs.

PCBs might have been used as coolant for the antenna electronics. It's also possible that operation of the antennae resulted in small PCB releases [USAF 2006]. In 1985, 54 drums of PCB contaminated soils were removed from the site [US Army/USAF 1994, Appendix A]. In 1986, 395 drums of PCB-contaminated soil were removed. The PCB contaminated soil—from both the 1985 and 1986 removals—came from an area on the southeast side of Antenna No. 2, an area on the west side of Antenna No. 3, and the southeast corner of the former composite building. Although as stated, the contaminated soil was shipped to Elmendorf Air Force Base [USAF 1996, 2006], no record of final disposal is available [USAF 1996; ADEC 2006]. ADEC records indicate that in 1986, soil contaminated with PCBs was removed in over-pack drums and shipped to the continental United States [ADEC 2008c]. ADEC records also indicate that 1 cubic yard super sacks were loaded into a shipping Container Express unit (CONEX) for transport off-site [ADEC 2008(a),07/31/2007].

Additional information pertaining to the disposition of wastes in the early 1980s was obtained by EMCON Alaska Inc., who interviewed former workers involved with cleanup activities [USAF 1996]:

> According to an EMCON Alaska, Inc. telephone interview of an engineer and equipment operator foreman of the 611 Civil Engineer Squadron (CES): In 1984 or 1985, PCB-contaminated soil from the radio relay station was placed in drums and soil samples from the drums were sent to a USAF lab in Texas [USAF 1996].
>
> According to an EMCON Alaska, Inc. interview with a manager at Philip Environmental, Inc., [formerly Northwest EnviroServices, Inc. (NWES), a State of Washington disposal facility] PCB-contaminated soil in the vicinity of the [radio relay station] composite building was removed to a depth of approximately 3 feet. Soil was placed into super sacks and into approximately 150 wooden boxes for shipment. The cleanup level for PCBs was 25 mg/kg [USAF 1996].

Former Composite Building and Surrounding Areas at the Radio Relay Station

- During 1987 and 1988, Aroclor 1260 was detected in 80 soil samples collected from the north end of the former composite building [USAF 1996]. PCB-contaminated soils were present along the northern wall up to 190 mg/kg. In 1990, PCB-contaminated soil was removed from this area until concentrations were below 10 mg/kg in field samples and below 25 mg/kg in laboratory analyzed samples.
- In 1990, the USACE removed PCB-contaminated soil from the former composite building excavations. Approximately 58 drums or 170 cubic yards of soil removed from the radio relay station and another area site were sent to APTUS Environmental Services in Kansas and incinerated [USAF 1996; Keres 2008]. Sludge containing PCB was removed from the concrete floor trench to a final level of 1.4 mg/kg [ADEC 2008(c)].
- During the 2004 Remedial Investigation, the concrete pads and soil around the pads were sampled for PCBs [USAF 2006; ADEC 2008(c)]. Three of 8 concrete samples from Antenna Pads 2 and 4contained PCBs above 1 mg/kg. Soil samples were collected from the top 2 feet of native soil and from 4 to 6 feet below the top of native soil. Two of 26 soil samples contained PCBs exceeding 1 mg/kg; Contamination was found in the soil at Antenna Pad 1 (estimated at 1.1 mg/kg) and Pad 2 (estimated at 15 mg/kg). Three of the pads were covered with clean soil (PCBs were not detected at 1 mg/kg), with the fourth left uncovered.
- Forty surface soil samples were collected in removal areas, including the radio relay station. *Aroclor 1260 ranged from estimates of 1.1 to the maximum of 930 mg/kg (Sample PG2-SB-01-S01-0)*. Another surface-soil sample contained 260 mg/kg Aroclor 1260 (Sample PG1-SS-07-S01-0) [ADEC 2008(c)]. Subsurface results indicated that PCBs were confined mainly to the upper 3 feet of soil; one subsurface soil sample (PG1-SB-02-S02-0) had an estimated concentration of 1 mg/kg Aroclor 1260 at a depth of 4–6 feet below ground surface (bgs). Contractors collected 32 subsurface soil samples [USAF 2006]. These soil results are summarized in Table 2.
- Cover soil placed over the foundation of the composite building after former soil removals contained PCBs exceeding 1 mg/kg; results from 10 samples ranged from 1 to 6.4 mg/kg Aroclor 1260.

> The cleanup level for PCB-contaminated soil and water were used as screening criteria at Port Heiden. Screening criteria are numbers or levels of contaminants in particular substances (soil, sediment, water). Typically, levels below screening criteria are not considered harmful to people.Those above them require further evaluation.
>
> The PCB (Aroclor 1260) cleanup level at Port Heiden RRS is 1 mg/kg (ppm) for soil (unrestricted use) and 0.5 µg/l (ppb) [or 0.0005 mg/l or ppm] for water. The USAF plans to excavate PCB-contaminated soil from the radio relay station areas and conduct confirmation sampling.

- Nine samples collected at the north side of the FCB exceeded 1 mg/kg PCBs, with concentrations ranging from 1.3 to 10 mg/kg. Soil with PCB concentrations below 10 mg/kg was placed into the soil covers of Landfills A and B. Landfill A is east of the FCB and Landfill B (Figure 2) is near the west end of the runway [USAF 1996; North Wind] 2012]. Both of these landfills were filled with demolition debris from the former composite building.
- Additionally, some samples were collected in other media besides soil. Water analyses from pad grid areas 1 and 3 detected 1.2 to 5.6 ug/L (micrograms per liter or ppb: parts per billion) Aroclor 1260, which is above the 0.5-µg/L screening criteria for water. PCBs were detected in two samples of black crowberries (*E. nigrum*)[5] near the radio relay station antenna pads at 0.19 and 0.069 mg/kg (or ppm: parts per million) [USAF 2006].

Auto Shop

In 1986, the USACE's site investigation found PCBs up to 15 mg/kg in the vicinity of the former composite building auto shop. This building was used into the 1970s. As previously discussed, the FCB concrete slab and some soils contained PCBs.

Drum Storage Area

The drum storage area is to the northwest of the FCB in the vicinity of the Former Facility Area pad. Antenna No. 3 was also in this vicinity. During a test pit excavation Aroclor 1260 estimated at 3.4 mg/kg was found in a soil sample collected under empty buried drums. Eight test pits were dug between the buried water tank and the south end of the drum storage area. Aroclor 1260 at 2.5 mg/kg was found in a powder/soil mixture recovered during excavation.

During the 2004 remedial investigation, PCBs were detected up to 9.9 mg/kg in surface soil in this area [USAF 2006]. Twenty-eight soil samples were taken in the drum storage area during the RI/FS; 13 surface and 6 subsurface soil samples. In general, surface soil samples were taken from 0 to 3 feet below ground surface (bgs) and subsurface samples were taken from 3 to 15 feet bgs.[6] The highest PCB result in surface soil was 19 mg/kg (DSA-SS-12-S01-0) in the northwest corner of the drum storage area. Noted here was an area approximately 35 feet in diameter of stressed vegetation—possibly from a surface spill. This area was sampled further during a focus area confirmation sampling. Eleven samples were taken for PCB analysis, but did not contain PCBs exceeding screening criteria. All 13 surface soil samples exceeded the Aroclor 1260 screening criteria of 1 mg/kg, while one subsurface soil exceeded it at 1.1 mg/kg (sample DSA-SB-05 collected from 4 to 6 feet bgs). Six additional surface soil samples were taken from the

[5] Four composite samples were taken from sites across the RRS and washed before analyses.
[6] ATSDR considers surface soil to be limited to a depth of less than 3 inches.

FFA pad, with one Aroclor-1260 result estimated at 5.4 mg/kg (southeastern portion of the pad near the FCB). This contamination, however, was not extensive and appeared confined to soil immediately under the drums [USAF 2006].

In 2009, samples were taken to delineate contamination in the drum storage area [USAF 2010]. PCB analytical results indicated a maximum of 140 mg/kg and 21% of the samples exceeding 1 mg/kg (Table 4). Although most contaminated soil was excavated and removed, some contaminated soil remains in this area.

Aroclor 1260 exceeding U.S. EPA's 0.5-µg/l (0.0005 mg/l) screening criteria was detected at 7.2 µg/l (0.0072 mg/l) in a groundwater grab sample from the drum storage area; but it's been reported as a likely result of cross-contamination from the drilling process [USAF 2006].

Diamond Area- Southern portion of drum storage area

PCB contamination was found 88 feet northwest of the northwest corner of the former composite building and southeast of the drum storage area. In three samples taken in 1990, PCB concentrations ranged from less than 1 mg/kg to 2.2 mg/kg [USAF 1996]. Contaminated soil was removed and sent to a Kansas incinerator [USAF 2006].

Former Pipeline Corridor (SS006)

Of 11 former pipeline corridor surface soil samples and 1 subsurface soil sample analyzed for PCBs, none exceeded PCB screening criteria.

Foundation Cover Soil/Pad Grid 1

In summer 2009, the boundaries of contaminated areas based on RI data were established for the Foundation Cover Soil/Pad Grid 1 area [USAF 2010]. The highest PCB concentrations found at the radio relay station site were found in this area (Table 4). PCBs in four subsurface samples exceeded the 930-mg/kg site maximum (the RI maximum for soil in the upper 2 feet found at pad grid 2) The PCB concentrations ranged from 980 to 4,800 mg/kg. [USAF 2010]. Some high-level contamination (over 1,000 mg/kg) was removed in 2009.

Table 2. Aroclor 1260 in Soil of Area 1

Former Facility Area (FFA), Investigation Area	*Location*	*Conc. Range (mg/kg or ppm) at or exceeding 1 mg/kg*	*Number of results at or exceeding 1 ppm/ #of sample results*	*Percent (%) of results > 1 mg/kg*
1	Pad Grid 1*	1- 260 F	6/24****	25
	Pad Grid 2	1.4- 930 J	6/16	38
	Pad Grid 3	2.3- 60	6/19	32
	Former Composite Building	1- 6.4	11	100
	Drum Storage Area**	1.5- 19	15	100
	Radio Relay Station Focus Area Confirmation Sampling, Antenna Pads***	1.1- 15	3/60	5

Analytical data from Port Heiden Radio Relay Station Remedial Investigation/Feasibility Study, April 2006 [USAF 2006]. Most soil data were analyzed by US EPA SW 846, Method 8082. Soil samples were taken from the upper 2 feet.

F- the value is below the reporting limit (the level employed during analysis to detect the presence of the analyte)

J- the value is an estimate

* Pad Grids 1 through 3 are located around the FCB in the vicinity of the antenna pads. The pad grids are contaminated soil removal areas.

** 1.1 mg/kg found in subsurface sample at 4 to 6 feet bgs.

***Aroclor 1260 in concrete of the footings from the antenna pads was 1.1 to 2.6 mg/kg.

**** 4 rejected samples were not included in the # of sample results or the %.

Notes: Additionally, one soil sample was taken at a Debris Burial Site (at 2.5 feet bgs) and had an Aroclor 1260 result of 3.4 mg/kg.

Figure 4. PCBs Exceeding 1 mg/kg in Soil at the Radio Relay Station

Source: USAF 2006, Volume 1, Figure 2-2

Area 2 – Radio Relay Station (North) Landfill

During radio relay station operations, the USAF disposed of wastes in the radio relay station landfill (also referred to as the North Landfill or LF007). From 1990 through 1992, the USACE demolished all buildings and structures at the radio relay station and buried the scrap materials in a landfill just east of the radio relay station gravel pad. The landfill surface is approximately 900 square feet, with the buried debris in the landfill taking up some 300 by 400 feet. During the 2004 RI, an investigation around the landfill perimeter found no contaminants detected above the USAF screening criteria in surface or subsurface soil. But PCBs, polycyclic aromatic hydrocarbons (PAHs), and pesticides were detected above screening criteria in the soil-cover material placed over the landfill [USAF 2006]. During the RI, an area with partially buried rusted drums was noted in the north central portion of the landfill.

Three of 8 soil-cover samples at the radio relay station contained PCBs exceeding the screening criteria. The maximum concentration was estimated at 360 mg/kg. Twelve subsurface perimeter soil samples did not contain PCBs exceeding the screening criteria. The aerial extent of buried debris in the landfill is approximately 300 by 400 feet.

In 2009, sampling was conducted to delineate the boundaries of PCB- contaminated soil at this landfill [USAF 2010]. The maximum PCB concentration was 280 mg/kg (Table 4). Approximately 25% of the samples collected contained PCBs exceeding 1 mg/kg [USAF 2010]. Approximately 10% of the analytical sample results exceeded 10 mg/kg (7 samples out of 69 total analytical results). The USAF plans to excavate PCB-contaminated soil from the radio relay station landfill and conduct confirmation sampling.

Table 3. Aroclor 1260 in Soil of Areas 2, 3, and 4 collected in 2004

Federal Facility Area (FFA) Investigation Area	Location	Conc. Range (mg/kg) at or exceeding 1 mg/kg	Number of results at or exceeding 1 mg/kg /# of sample results	Percent (%) of results > 1 mg/kg
2	Radio Relay Station/North Landfill Cover Soil	4.6- 360 J	3/8	38
3	Septic Tank*	1.1- 440 J*	9/18**	50
4	Septic System Outfall	2.6- 7.2 J	4/28	14

RI/FS 2004 analytical data from Port Heiden Radio Relay Station Remedial Investigation/Feasibility Study, April 2006 [USAF 2006]. Most soil data were analyzed by US EPA SW 846, Method 8082. Surface soil samples were taken from the upper 2 feet.

J means the concentration is an estimate.

*During a 1999 site inspection, a sample was reported to contain "13,100 ppm of "PCBs and pesticides" at the septic tank area [USAF 2000].

**3 sample results were rejected and not included in the # of sample results or the %.

Table 4. PCB Analytical Results from Radio Relay Station Soil Collected in 2009

Former Facility Area (FFA), Investigation Area	Location	Conc. Range (mg/kg) at or exceeding 1 mg/kg	Number of results at or exceeding 1 mg/kg/ # of sample results	Percent (%) of results > 1 mg/kg
1	Foundation Cover Soils/Pad Grid 1	1.0 – 4800	92/348	26
1	Drum Storage Area	1.1 – 140	44/211	21
2	Radio Relay Station/North Landfill	1.1 – 280	16/63	25
3/4	Black Lagoon Outfall, Former Septic Tank, Septic System Outfall	1.1 – 360	16/109	15

Analytical data from plates in Port Heiden Radio Relay Station Final Report (draft- June 2010) [USAF 2010]. Soil samples were taken from the upper 2 feet (typically 1.5 feet bgs) in Summer 2009.

Area 3 – Black Lagoon Outfall and Pipeline, Septic Tank, and Septic System Pipeline

The Black Lagoon outfall received wastes poured into a floor drain in the former composite building garage. Petroleum hydrocarbons (TPH)—not PCBs—was the predominant contaminant at this petroleum waste-area lagoon. But results indicated that PCBs had been introduced into the septic system during radio relay station operations [USAF 2006].

In 1987 and 1988, USACE collected and analyzed for PCBs and other contaminants four samples from the Black Lagoon Outfall. PCBs were analyzed using U.S. EPA Method 8270 and found present at low levels. PCBs were also present in the surface soil in the vicinity of the septic tank and in pipeline material. Aroclor 1260 (0.29J- 6.9 mg/kg, 4 samples) was found in pipeline material from the Septic System Pipeline.

During the 1990 Defense Environmental Restoration Program cleanup, 22 surface soil samples were analyzed for PCBs, but no PCBs were detected [USAF 1996]. Remediation based on TPH contamination was recommended as early as 1996. During a 1999 site inspection, five soil samples were collected and one sample reportedly "contained Aroclor 1260 at a concentration of 13,100 ppm" [ADEC 2006; section 2.1.4.1]. The Army Corps of Engineers received a data validation draft of this report together with a laboratory report that contained the 13,100 ppm value under a column marked "PCBs and Pesticides" [USAF 2000]. Little available information, however, describes how or at what depth the sample was collected.

During the remedial investigation, septic tank soil samples indicated that Aroclor 1260 was present in soil above 1 mg/kg (estimated at 1.1 to 440 mg/kg) [Table 3] [USAF 2006]. The soil samples were collected from the upper 2 feet of soil, with one subsurface sample at 4 to 6 feet bgs, with an estimated result of 1.1 mg/kg Aroclor 1260. The septic tank was removed in 1990 [ADEC 2008f].

In the summer of 2009, sample results in the area of the septic tank indicated a PCB maximum of 360 mg/kg (Table 4). Three sections have remaining PCB contamination between 1 and 10 mg/kg with petroleum oil and lubricant (POL) stains and odor near these grids. Although some soil in this area was excavated, none of the POL/PCB-stained soil was transported to the Native Village of Port Heiden (Class III) Landfill; thus a part of Area 3 remains where PCBs exceed 10 mg/kg [USAF 2010].

Area 4 – Septic System Outfall

Ten surface soil samples characterized the septic system outfall for PCBs. Two surface soil samples contained approximately 7.2 mg/kg Aroclor 1260. Four samples contained Aroclor 1260 above 1 mg/kg (Table 3) [USAF 2006]. PCBs did not exceed the screening criteria in the seven other samples.

Roadway Spills and Contamination

On July 30, 2009, a mostly empty dump truck returning from the New Village of Port Heiden (Class III) Landfill rolled over on its way back to the radio relay station site [USAF 2010]. Although the truck had already dumped soil at the landfill, a small amount of residual soil came out of the truck bed. As a result of the roll-over incident, 10 surface samples collected from the road surface at a depth of 0.5 to 3 inches showed PCBs ranged from less than 1 mg/kg to 12 mg/kg.[7] On September 9, 2009, contaminated soil was removed and placed into super sacks for off-site disposal.

On August 19, 2009, Weston began transporting soil from the soil-washing facility to the Native Village of Port Heiden (Class III) Landfill for disposal [USAF 2010]. Analytical testing indicated the treated soil contained less than 10 mg/kg PCBs. Leakage of contaminated soil from improperly secured tailgates resulted in up to 5 gallons of treated soil spilling onto the roadway. Analytical results from samples taken before grading of the roadway showed three locations with PCBs exceeding 1 mg/kg: at the entrance to the radio relay station site, 1 mile from the entrance, and 1.5 miles from the entrance. After roadway grading, analytical results at these three locations remained above 1 mg/kg PCBs, with one location above 10 mg/kg (at 19 mg/kg). Scraped soil from grading was loaded into dump trucks and hauled to the NVPH (Class III) Landfill.

In 2010, in response to community concerns, additional samples were taken on the roadway and in early 2011 samples were taken along the shoulders at various depths. Community members used the road to haul subsistence foods back to their homes and were concerned about inhalation and ingestion of dusts. Initial results (draft) indicated Aroclor 1260 concentrations ranging from not detectable to 69.4 mg/kg. In 2011, USAF ordered a time-critical removal action of PCB-contaminated access road soil from the airport to the radio relay station site [USAF 2011]. Three locations had levels of Aroclor 1260 exceeding the 50 mg/kg level—where contaminated soil becomes a Toxic Substances Control Act (TSCA) regulated waste. The three locations included the radio relay station pads with 69.4 and 59.7 mg/kg; sample Road-11 at 60.6 mg/kg; and sample Road-01 at 66.0 mg/kg [draft sample results from USAF 2011]. TSCA regulated wastes were segregated and stored in specific containers for off-site disposal at a TSCA-regulated disposal facility [USAF 2011]. Non-TSCA regulated wastes were stored for off-site disposal in accordance with ADEC regulations. Further, non-TSCA excavations will be conducted along the road. Investigations in 10 Fort Morrow sections have not found PCBs at levels above 1 mg/kg [USACE 2013].

[7] Some previous PCB contamination to the roadway is suspected.

No Evidence of PCBs in Domestic Port Heiden Well Water

According to information in the RI/FS, groundwater at the Former Facility Area flows to the north, away from the village of Port Heiden and the former village of Port Heiden. Thus, Port Heiden Private wells are not contaminated by FFA groundwater plumes [USAF 2006].

In 2003, Keres Environmental sampled water wells in Port Heiden under the Native American Lands Environmental Mitigation Program. Wells were tested for VOCs, PAHs, PCBs, and metals [ADEC 2008e]. PCB results for Aroclors 1016, 1221, 1232, 1242, 1248, 1254, and 1260 were obtained from the drinking water quality investigation of 42 domestic wells in the native village of Port Heiden. Sample test results were all below the detection levels (0.25 µg/l for all Aroclors except for Aroclor 1221 which was 0.5 µg/l) [Keres 2003, 2008].

In the former village of Meshik, private water wells also supplied the village with domestic water. Around 1994, approximately 10 residents remained in Meshik [USAF 1994]. Although some water quality data were available [USACE 1979], we found no information on whether potential contaminants, such as PCBs, were sampled in the water supply. Nevertheless, while no PCB data at all are available for the wells in the former village, the wells are farther away from the radio relay station than are the wells in the current village.

Community Concerns

Tribal members' principal concerns were possible effects to human health through contaminated lands and subsistence resources. Although the Former Facility Area, including the radio relay station area, had been characterized, work remained on characterization of the larger Fort Morrow site.

In 1988, ADEC received a copy of a letter from the Alaska Department of Health and Social Services (DHSS), Division of Public Health, to U.S. EPA [ADEC 2008e]. The letter contained an observation that 30–40% of women who live year-round in the village of Port Heiden had abnormal pap smears, some developing into cancer. The pap smears of these women were more abnormal than the pap smears of their relatives in Pilot Point and Chignik. The letter also contained a concern about gonadal cancer. The ADEC record indicates that a staff member was concerned about possible connections between these cancers and U.S. Army refuse and contamination [ADEC 2008a and e].

In 2002, following circulation of the 1988 letter, the Corps of Engineers and Air Force held a public meeting with ADEC and public participation [ADEC 2008f]. Many residents expressed concern over health problems and a possible link between these problems and past military activities. Residents were also generally concerned about excess cancers detected in the former Village of Meshik.

And the Native Council of Port Heiden raised concerns about effects of PCB contamination on human health and on the environmental resources residents use for subsistence [Native Council of Port Heiden 2007]. The council reported estimates of cancer rates in Port Heiden 10 times those in adjacent communities, with some families experiencing cancer rates of 50%. The council reported that an estimated 95% of children in Port Heiden had had ear infections, and that skin infections and upper respiratory conditions, such as asthma, were frequent [Native Council of Port Heiden 2007].

In 2007, representatives from the Village of Port Heiden reported that the tribe's subsistence items were affected as a result of the Fort Morrow/Port Heiden Radio relay station site [Keres 2008]. Subsistence foods used by the tribe [e.g., clam, shrimp, fish (including salmon), eel, birds (including duck and geese) and their eggs, porcupine, caribou, bear, ptarmigan, tea, and berries (including blackberries, cranberries, blueberries, and "wine" berries)] were potentially affected by site contaminants, including PCBs. Land animals used for subsistence by the tribe foraged at the radio relay station site. Caribou was preferred by many, but Caribou hunting was banned except for special ceremonies [Keres 2008; ATSDR 2008].

The Air Force posted signs at the radio relay station that said "do not gather subsistence items at this site" [Keres 2008]. Although some tribal members had food safety concerns about other Fort Morrow areas, no other areas were posted.

Response to Community Concerns

Noncancer Community Concerns

Summarized noncancer concerns were

1. Ear infections
2. Skin infections
3. Upper respiratory conditions such as asthma

Reports had been received of similar concerns from other PCB-contaminated communities in the Arctic and elsewhere, as discussed below. Reasons for the high incidence of middle ear and pulmonary (lung) infections, however, remain unknown or unclear.

Ear and lung infections in other populations

In the town of Yucheng, Taiwan, consumption of PCB- and polychlorinated dibenzofuran-contaminated oil led to an accidental poisoning in 1978 and 1979. It is important to note that the amount of PCBs and polychlorinated dibenzofurans ingested in Yucheng was significantly higher than what may occur at Port Heiden. Mothers reported that babies up to 6 months of age who were exposed to PCBs had more pneumonia or bronchitis or both than babies who were not so exposed. Yucheng children also had a higher incidence of middle-ear diseases (otitis media) than their matched controls [Chao et al. 1997]. The Yucheng children contracted otitis media easily or had difficulty clearing the infection. One study found a possible connection between the ability of the baby's bodies to resist middle ear infection and exposure to PCBs [Chao et al. 1997]. While the study established a PCB-ear association, these were high-exposure poisonings, not low-level exposures. Appendix D summarizes further information on the Yucheng incident and other communities affected by PCBs.

Dewailly et al. [2000] investigated whether organochlorine (OC) (with immunotoxic properties) exposure was associated with the incidence of infectious diseases in Inuit infants from Nunavik (Arctic Quebec, Canada). Contamination of the Arctic aquatic food chain by organochlorine compounds (OCs) such as PCBs, polychlorinated dibenzodioxins (PCDD) and polychlorinated dibenzofurans (PCDFs) had been documented. The major source of OC exposure in Inuit people was sea mammal fat consumption. Native children from Nunavik had a high incidence of infectious diseases, in particular meningitis, bronchopulmonary, and middle ear infections. Acute otitis media was the most frequent health problem among Inuit newborns during the first year of life, with 80.5% of all infants experiencing one or more episodes. Dewailly and colleagues and reported an association between prenatal organochlorine exposure and acute otitis media in Inuit infants [Dewailly et al. 2000]. Dewailly and colleagues added, however, that the actual reason for the high incidence of middle ear infections in Inuit children was unknown. Inuit in Nunavik reported hearing loss as their most common chronic health problem. The second most frequent health problem was pulmonary infections. Ear infections can lead to significant hearing loss. The authors stated that a reduction of organochlorine body burden in Inuit women of reproductive age appeared desirable.

Asthma

In our review of PCBs, no information was found for an association specifically with asthma.

Skin Infections

Skin conditions, such as acne and rashes, might occur in people occupationally exposed to products containing PCBs (ATSDR 2000a). Chloracne, a skin condition resembling acne, is the most easily recognizable effect of PCB exposure in humans (ATSDR 2000a).

Noncancerous Health Effects

Our dose estimates for noncancerous health effects (Appendix A, Tables A-1 and A-2) indicate that Port Heiden residents are unlikely to experience these effects based on their exposure to PCBs measured in the accessible soil since 1990. This is because the areas of higher concentrations are not likely to be frequented in the immediate future. We estimate that if PCB levels found in the restricted areas (84.5 mg/kg) were found in areas that could be contacted, contact would need to be restricted. Additionally, soil levels near 10 mg/kg are estimated to exceed the MRL for a current subsistent child. Therefore, it is prudent to consider re-evaluating exposures should new areas with concentrations near 10 mg/kg be discovered (See Appendix A).

Although current exposures to the more contaminated soils is expected to be rare and infrequent, residents might still be exposed to PCBs in subsistence foods from land and ocean ecosystems (e.g., clams, walruses, birds, berries) that could be contaminated with PCBs related to the Port Heiden radio relay station site. And Alaska natives commonly use seal oil as a preservative for the long-term storage of plant and animal materials for food; the oil prevents spoilage and acts as an antibacterial agent [ATSDR 2001a]. Appendix B provides further discussion of subsistence foods.

Studies [Chao et al. 1997; Dewailly et al. 2000] indicate a relationship between organochlorines—including PCBs—and suppression of the immune system that might lead to adverse health effects. Because exposure to PCBs might contribute to meningitis, bronchopulmonary conditions, and middle ear infections (possibly leading to hearing loss), *a reduced body burden of PCBs is desirable*. Additionally, limited data on subsistence foods indicate the need for additional sampling.

This and related health information could help residents make dietary choices, such as which and how much natural subsistence foods to consume and which to avoid or substitute.

Community Cancer Concerns

Summarized community cancer concerns were

1. Abnormal pap smears with some developing into cancer
2. Gonadal (reproductive organs-ovaries and testes) cancer
3. An excess number of cancers

Although exposure to PCBs in soil might have slightly increased the Port Heiden population’s cancer risk, dose estimates are many orders of magnitude lower than doses producing cancerous effects in animals. These estimates suggest that ingestion of soil containing PCBs at the radio relay station site is unlikely to cause cancer in people (Appendix A, Table A-3; Appendix A also includes a section summarizing U.S. EPA’s risk assessment for soil at the Former Facility Area). In the PCB literature we reviewed, we didn’t find the specific cancer concerns listed here, such as gonadal cancer. But many other factors can elevate cancer risk (e.g., smoking, diet, exposure to other contaminants/carcinogens).

In a large study of cancer mortality, Kimbrough et al. [2003] assessed risk related to PCB exposure of capacitor workers heavily exposed to PCBs at plants in the State of New York. Kimbrough and colleagues found no associations with cancer, but did find that all cancer-combined mortality actually decreased. Aroclors 1254, 1242, and 1016 were used at these plants [Kimbrough et al. 2003]. According to Shields [2011], insufficient data in experimental animal studies prevented any finding that PCBs were carcinogens. And the epidemiologic evidence failed to establish PCBs as human carcinogens. Cancers reported in the literature as elevated in PCB-exposed cohorts (e.g., occupational studies of workers) were malignant melanoma, liver, rectum, gastrointestinal tract, brain, and hematopoietic [Kimbrough et al. 2003]. Laboratory animal studies showed that PCBs might act as modifying agents following exposure to known carcinogens, acting as both tumor promoters and inhibitors [Shields 2011]. Shields identified four studies that found Aroclor 1260 induced hepatocellular carcinomas (liver cancer) in laboratory mice and rats exposed to large doses over a lifetime [Shields 2006]. But Shields pointed out the many pathologic dissimilarities between experimental animal tumors induced by PCBs and human liver cancer. Appendix F has additional information on cancer and PCBs.

Kimbrough et al. [2010] found that except in extraordinary circumstances, PCBs in soils were unlikely to increase human body burdens. One such case was found in Anniston, Al where PCBs were manufactured for over four decades [ATSDR 2000b]. Studies are underway today to examine the associations between health effects and those unusually high body burdens in Anniston [Silverstone et al. 2012]. Conversely, relatively low body burdens were found in the subsistence island community of Saipan, which had high levels of PCB contamination from WW II military use [ATSDR 2001a]. The Port Heiden residents share some similarities with the Saipan community as those in Port Heiden were also exposed to PCBs in subsistence foods (e.g., clams, walruses, birds, berries, and plants) that could have been contaminated by PCBs related to the Port Heiden radio relay site. Yet the extent of contamination in all the Port Heiden foods is not well-known. Therefore, prudent public health practice would call for *a reduced body burden of PCBs*. Evaluation of Potential Public Health Hazards, below, contains further discussion on this issue, and Appendix B contains further discussion on subsistence foods.

Community Concerns for Fort Morrow Areas Not Previously Investigated

The Corps of Engineers began investigating the Fort Morrow FUDS in 2012. A draft report of 10 of the Corps'13 areas indicates PCB concentrations in soil below 1 mg/kg [USACE 2013].

Evaluation of Potential Public Health Hazards

Figure 5 describes the exposure evaluation process ATSDR followed. ATSDR emphasizes that a public health hazard is present only if exposure to a hazardous substance occurs at sufficient concentration, frequency, and duration for harmful effects to occur. People who hunted or foraged for food at the radio relay site could have been exposed to PCB contamination through incidental (accidental) ingestion of contaminated soil, dermal contact with the soil, ingestion of subsistence foods grown in PCB-contaminated soil, and ingestion of mammals (herbivores) that consumed onsite vegetation grown in PCB-contaminated soil. Workers hired to assist with soil removals and site cleanup were also a potentially exposed population.

Both land and ocean ecosystems have been affected by activities associated with the radio relay area. Bristol Bay is of concern due to an eroding landfill near the former village of Meshik. Figures 6 and 7 detail the food chain pathways in these ecosystems. Appendices A through G contain detailed information on dose estimates, health effects, studies of other PCB-exposed communities, and other information.

Exposure to PCBs in Soil at the WACS/Radio Relay Station Site

Although exposure to PCBs has not been documented by an exposure investigation, ATSDR considers the residents of the new village of Port Heiden as an exposed population. Residents are in close proximity to the radio relay site—a PCB contaminated area—and live within the larger Fort Morrow Formerly Used Defense Site. No permanent Port Heiden resident has ever lived on the radio relay site nor does anyone live there today. Overall, because of past contaminated-soil removals, today's exposure is expected to be low. And although past exposure is unknown, the exposed population would only be limited to those persons who had access to the radio relay site and, if they brought the contamination home with them, possibly their family members.

Migration of the majority of residents from the village of Meshik to the village of Port Heiden in the 1970s means that residents were in the Formerly Used Defense Site area when the earliest removals occurred in the 1980s. During the 1980s, over 400 drums of contaminated soil were removed from the radio relay site. No records document PCB concentrations for the first soil removal or for the debris buried in 1984; thus we can't construct accurately any worst-case scenario based on the highest PCB concentrations. We do know, however, that contaminated soil was removed from the site in the 1980s and 1990s. We also know that maximum soil concentrations for the remaining soil in several FUDS areas were in the hundreds of mg/kg for Aroclor 1260 and perhaps up to 13,100 mg/kg, as indicated in one report [USAF 2000]. And because of residual contamination from past cleanups, some hotspots of PCB contaminated surface soil (10–20 mg/kg) might remain. Finally, we know that low-level PCB-contaminated soil was used as fill material to regrade the radio relay site [USAF 2006].

Although the majority of known PCB-contaminated soil and materials have been removed from the radio relay site, people could have been exposed to PCBs through dermal contact or accidental ingestion of soil during foraging, hunting, or other site-related activities. Although, again, no one lives on the radio relay site, for benchmark purposes U.S. EPA's established soil clean-up level for PCBs in residential settings is 1 mg/kg.

No congener data are available for the environmental samples taken at the radio relay site. Although total Aroclors (only Aroclor 1260 was deemed present) in soil is sufficient for an estimate of PCB concentrations, congener-specific data are preferable.

Exposure doses for Aroclor 1260 in soil have been calculated for subsistence children and adults at the radio relay site as well as for short-term and long-term workers. Tables A-1 through A-3 of Appendix A show the exposure doses for noncancer and cancer effects.

Exposure to PCBs through the Food Chain

The more toxic, high-chlorine PCB compounds accumulate in plants and animals in the environment (bioaccumulate). These bioaccumulated PCB compounds can be even more toxic than the original PCB commercial mixtures (Aroclors), can persist in the body, and can continue biological activity even after exposure stops [Cogliano 1998].

Arctic organisms tend to have nutrient storage tissues such as fleshy root structures or fat stores. Plants growing in soils containing high concentrations of PCBs could be toxic to grazing animals. A human diet composed of lipid-rich Arctic wildlife could result in elevated PCB levels. People of northern Arctic communities living near local PCBs sources are likely to have higher body burdens compared with other, more southern populations not living near such sources. As PCBs travel up the food chain, they're magnified and reach the highest levels in animals at the food chain apex (e.g., humans, whales). Figures 6 and 7 show food chain diagrams.

Although the nutritional advantages of naturally grown foods might outweigh any PCB risk, Port Heiden residents should receive more information on PCBs in traditional subsistence foods. Such information will allow them to make choices on whether to consume or use such foods, to limit their consumption, or gather food from less-contaminated areas. Table 4 indicates PCBs in tissues of various Arctic organisms (not site-specific) and shows higher PCB concentrations in animals higher in the food chain (Figures 6 and 7). Table 5 shows total PCBs in tissue (e.g., fat, liver, and muscle) of Arctic organisms. *Chronic exposure to PCBs through local subsistence foods, especially foods of animal origin (land and ocean), is probably the main source for PCBs in the diets of Port Heiden residents.* PCB contamination of the marine foods in the Arctic is due to many sources. Contaminants, including PCBs travel through the air from sources worldwide and are deposited into water and accumulate through the marine food web. Worldwide air and water currents bring pollution to the Arctic. While most of the marine pollution is due to several sources, some Port Heiden pollutants[8] were reported to have entered the marine environment in the past [USACE 1976; North Wind 2012]. The known areas of PCB-contamination in Port

[8] While there is documentation of general pollution entering the marine environment, we suspect that relay station PCB contamination was limited to mostly at the relay station and to a lesser degree in small hot-spot areas like those currently discovered.

Heiden have been contained and migration has been minimized [Triad 2013]. And although PCBs contamination was not just limited to the relay station on the hill as previously thought [USACE 1987; North Wind 2012], there is no current indication that the more recently found hot-spots are leaching PCBs toward the marine environment [Triad 2013]. Nevertheless, data is lacking to fully address the marine exposure pathway.

Table 5. Total PCBs (ppm) in Tissue of Arctic Organisms*

Tissue	***Fat***	***Liver***	***Muscle***
Land Organism:			
Polar Bear	3.0-8.0	No Info	8.0-250
Eider Duck	0.17-1.08	0.10-1.85	No Info
Caribou	0.003-0.07	0.33-0.59	No Info***
Arctic Hare	BD of 0.008	BD of 0.006	BD of 0.033
Marine Coastal or Ocean Organism:			
Whales Narwhal	<0.50-13.0 0.9-7.3	No Info No Info	No Info No Info
Sea Birds	<0.01-1.3	0.024-2.4	No Info
Ringed Seal**	0.3-0.8	0.4-1.7	0.26-4.0
Arctic Char	0.1-0.26	0.16-0.26	0.06-0.31
Arctic Cod	No Info	No Info	0.004 (wet) 0.003-0.005

*Selected data from Reimer et al. 1993, Vol. 1, Table IV-1 and table on p. 344. Data are not specific to the Port Heiden area. Tissue concentrations have been converted to ppm and rounded.

**Alaska natives are reported to use seal oil as a preservative for the long-term storage of plant materials for foods [ATSDR 2001a].

***Although there is no information on Carabou, ATSDR analyzed blood drawn from Reindeer muscle from St Lawrence Island near another relay station. No PCBs were detected in the blood (with a detection level of 25 ug/L) [ATSDR 2001c].

BD = below detection

Land plants and animals

Table 6. Predicted Concentrations of PCBs in Plants for Different Soil PCB Levels

Soil PCB Concentration (ppm)	***Predicted Plant PCB Concentration (ppm)***
0.5	0.023
1.0	0.10
1.6	0.20
2.0	0.26
5.0	0.74
10.0	1.5

Source: Reimer et al. 1993

Several site-specific data sources are available regionally to help evaluate land, plant, and animal exposure. Plants take up only small amounts of PCBs from the soil; some studies found small amounts of PCBs vapors to accumulate in the leaves and aboveground parts of plants and food crops [ATSDR 2000a; IDPH 2009]. Dust contaminated with very small levels of PCBs might be found on the outer surfaces of fruits and vegetables [IDPH 2009]. According to Reimer [1993], in Arctic plants associated with Canadian radar sites, both PCB adsorption to root surfaces and to aerial deposition on shoot surfaces appear important [Reimer et al. 1993].

Accumulation of PCBs in plants might occur either from deposition on shoot surfaces from local soil revolatilization or from adsorption to root surfaces in the soil. Plant congener signatures tended to reflect soil sources at the radio relay station site and emphasize the importance of the radar sites as local sources of PCB contamination to the ecosystem. In general, plant concentrations of PCBs are lower than the soil concentrations in which the plant is growing or grew; Reimer and colleagues used a regression equation (based on a simple linear equation of Y= 0.159X -56.7, where X= concentration in soil in ppb and Y= concentration in plants in ppb) to quantify the relationship between concentrations of PCBs in plants and soils (ppb converted to ppm in Table 6). Using this equation, concentrations of PCBs in vegetation were predicted for different soil levels. Appendix C has additional information on the Canadian radar sites.

In addition to the generalizable data available on Arctic plant uptake of PCBs, some limited, site-specific data are available for Aroclor 1260. Although total Aroclors (only Aroclor 1260 was deemed present) is sufficient for an estimate of PCB concentrations, congener-specific data for plants and animals is preferable.

- Crowberries growing near the radio relay station antenna pads had PCB concentrations below the Food and Drug Administration (FDA) limit of 0.2 parts per million (ppm) for commercially sold infant and junior foods [CFR 2009]. Doses estimated from the measured values (children ranged 1.52E-04 to 5.51E-05 mg/kg/day in children) were above ATSDR's intermediate and chronic minimal risk levels, MRLs (of 3E-05 and 2E-05). (See Appendix B for dose calculation and discussion). Although the crowberries alone do not exceed the FDA's limit, the community in Port Heiden also consumes other foods that could potentially contain PCBs and add to the total exposure dose. These foods include caribou, walrus, and cockles, all of which are consumed at a higher rate than crowberries in Port Heiden [USAF 2006]. ATSDR does not currently have any information on the concentration of PCBs in these additional sources of potential exposure, and thus, the total exposure from diet is unknown. Furthermore the PCB concentration in crowberries is directly related to that in soil, which has been shown to vary greatly with hotspots that would predict much higher concentrations in the crowberries. Since multiple foods will contribute to the overall exposure to PCBs with crowberries being just once source, the FDA limit (0.2 ppm) may not be sufficiently protective of people who are expected to have PCB exposures from other sources. The safest measure is to reduce the known exposure to PCBs and avoid eating crowberries from the contaminated area.

- No adverse health effects are anticipated from exposure to the site-specific PCBs Aroclor 1260 in small mammals. The doses were even lower than for crowberries at the radio relay station site. Still, the sampling was focused on Aroclor 1260, the site-related PCB-contamination, and not all congeners. While Aroclor 1260 was the dominant contaminant, for a complete health evaluation, we would have preferred to estimate dose using total Aroclors or a sum of the congener concentrations—those known to be associated with the site as well as other congeners present in Pacific seafood.

Appendix B contains more information on PCBs in food and a discussion of PCBs in crowberries and small mammals at the site.

Access to the FFA property and the radio relay station site was and is unrestricted. Signs (one example of several types is shown) are posted warning trespassers not to collect foods from the site. A variety of warning signs were posted in 1990s so there is a possibility of exposure to contaminants in food collected from the site before then. Additionally, residents could be exposed if they ignore the warning signs or if they consume animals that had grazed in contaminated areas or plants grown in contaminated soils. Although the majority of known PCB-contaminated soil and materials have been removed from the radio relay station site, people could have been, or could still be, exposed to PCBs through dermal contact or accidental ingestion of soil, and ingestion of wildlife or food sources containing PCBs.

In the final analysis, exposure to the PCB-contaminated soils and subsistence foods from the radio relay station site could have slightly increased the health risks for Village of Port Heiden residents.

Marine Organisms

No PCB concentrations in sediment or fish samples for lakes or rivers are available. Like most DEW line sites, the radio relay station site was constructed in proximity to the sea. Previous site activities are potential and likely sources of contaminants in the local marine environment. While no PCB data is available for the marine environment, data for other pollutants have been documented to enter the Port Heiden marine environment [USACE 1976; ATSDR 2014]. And while no PCBs have been found in the groundwater, there are PCBs in the surface soils along the roads from the relay station toward the airport [Triad 2013]. PCB's are not expected to migrate to the harbor from the currently identified hot-spots, but no sampling has been done to determine if PCBs were brought closer to the harbor whether it be deliberate for dust suppression or accidental when other waste materials were moved.

Bioaccumulation of contaminants such as PCBs by bottom-dwelling animals might serve as a major source of these substances to animals at higher levels in the food chain. Figure 6 shows typical food chains in the vicinity of radar sites. The Bristol Bay area is of concern due to an eroding community landfill near the former Village of Meshik and because of potential transport of contaminants from the site (via air, sediment, surface water, or groundwater pathways).

Coastal embayments that receive freshwater runoff are likely to be important areas of enhanced biological production and feeding grounds for birds and mammals. Figure 7 shows a typical arctic marine coastal and offshore food web. The bottom-dwelling animals of near-shore zones (e.g., soft-shell crab, mussels, sea urchins) are preyed upon by fish (Arctic cod, and the 4-horned sculpin). These organisms and fish are important food items for the ringed seal and other marine mammals. The benthic organisms are likely important components of the diet of marine birds. Bottom dwelling marine animals are potential food sources for predatory fish, marine birds, and mammals [Reimer et al. 1993]. The study of benthic and epibenthic animals (e.g., crabs, shrimp; Figure 7) is advantageous in that the animals are sedentary and thus reflect local contaminant inputs. Body burdens of PCBs may increase by a factor of approximately 3 billion through the marine food chain up to the top predator level [Reimer et al. 1993]. According to the subsistence food consumption estimates for the Port Heiden radio relay station area, Port Heiden residents consume many types of birds and their eggs [USAF 2006]. That said, no birds or their eggs were sampled for PCBs in the vicinity of Bristol Bay.

The observed biomagnifications of PCBs, as shown by the elevated concentrations in four-horned sculpins (*myoxocephalus quadricornis*) from Cambridge Bay, Northwest Territories (NWT, Canada) suggests that low-level local inputs have significant ecosystem effects [Reimer et al. 1993]. Four-horned sculpins contained the highest observed concentrations of PCBs of all marine samples. Sculpins are used by NWT natives in soup and may be used by Alaska Natives. Sculpin liver PCB concentrations (approximately 0.3 ppm maximum, 0.17 ppm average—

estimates from graph) were similar in magnitude to ringed seal blubber in Cambridge Bay [Reimer et al. 1993]. .

PCB accumulation in high-fat aquatic animals, such as walrus, seal, and otter, could be of particular importance to Port Heiden residents. Although polar bears, narwhal, and whales can be in the food chain of the typical Arctic marine food web (Figure 7), currently no polar bears or narwhal are in the Port Heiden area, and Port Heiden residents are not known to subsist on whales [personal communication, Louis Howard, ADEC, June 2011]. Although the radio relay station site might be contributing to the PCBs found in these aquatic animals, other potential sources are in the area (e.g., other radar sites).

Figure 5. ATSDR's Exposure Evaluation Process

REMEMBER: For a public health threat to exist, the following three conditions must all be met:

- Contaminants must exist in the environment
- People must come into contact with areas that have potential contamination
- The amount of contamination must be sufficient to affect people's health

Are the Environmental Media Contaminated?

ATSDR considers:

Soil
Ground water
Surface water and sediment
Air
Food sources

Are People Exposed To Areas With Potentially Contaminated Media?

For exposure to occur, contaminants must be in locations where people can contact them.

People may contact contaminants by any of the following three exposure routes:

Inhalation
Ingestion
Dermal absorption

For Each Completed Exposure Pathway, Will the Contamination Affect Public Health?

ATSDR will evaluate existing data on contaminant concentration and exposure duration and frequency.

ATSDR will also consider individual characteristics (such as age, gender, and lifestyle) of the exposed population that may influence the public health effects of contamination.

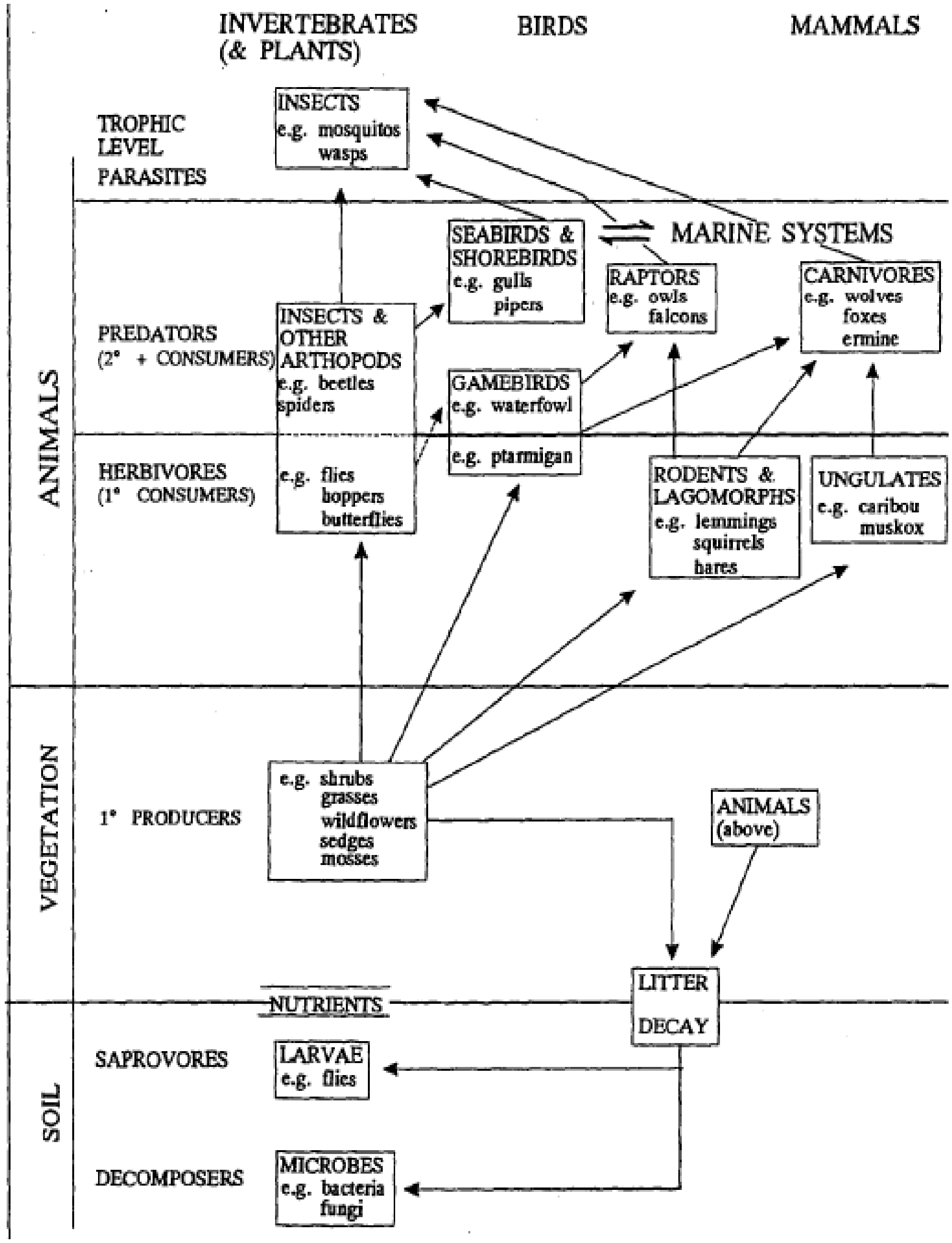


Figure 6. Typical Food Chains in the Vicinity of Radar Sites [modified from Reimer et al. 1993 which was adapted from Sage 1986]

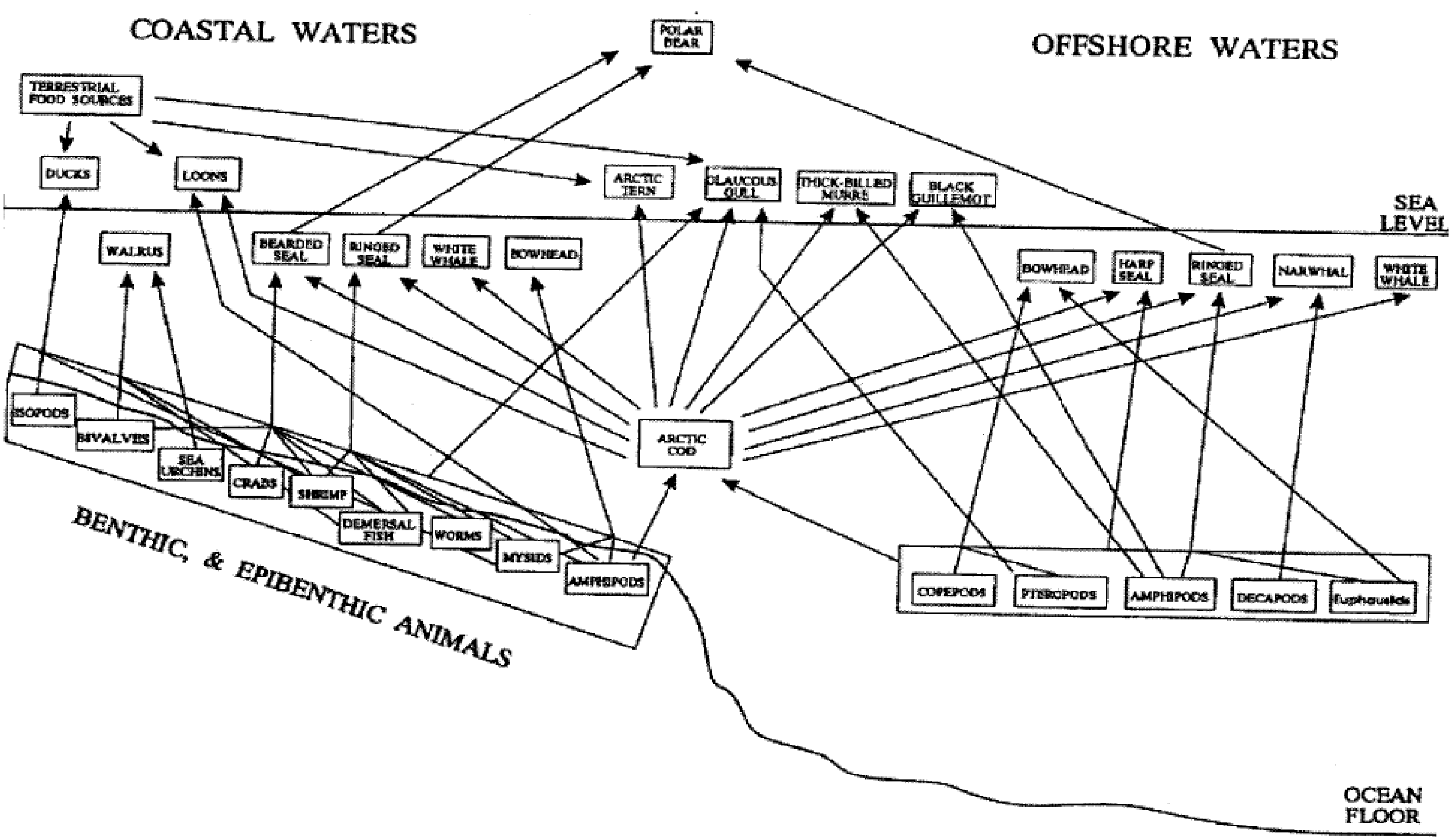


Figure 7. Diagram of Typical Arctic Marine Coastal and Offshore Food Web [modified from Reimer et al. 1993].

Although polar bears, narwhal, and whales can be part of the food chain in the typical Arctic marine food web, currently no polar bears or narwhal inhabit the Port Heiden area, and Port Heiden residents are not known to subsist on whales.

Data Gaps

The following data gaps, if filled, could help health agencies to provide better recommendations to the Port Heiden community:

1. **Provision of the PCB occupational blood sampling results for village workers**. All references to blood PCBs of Native Alaskans of this region are more than 10 years old. The values were elevated in the past—relative to the U.S. population generally—because the Alaskan Native diet included large amounts of Pacific mammals and fish that contained PCBs. Given that the highest levels of PCBs have been declining in the marine environment, we suspect that the PCBs are decreasing in Native Alaskans as well; this is as yet unproven, however.
2. **Collection of PCB soil data from additional areas.** Collection should occur:
    - along roads in the village;
    - in residential yards in the village (if found along roads);
    - and possibly at burial sites (if evidence of oils exist).
3. **Further characterization of the subsistence foods most often consumed by the Port Heiden community and that are most likely to accumulate PCBs.** Total Aroclors or a sum of the congeners (preferred) in land and ocean subsistence food items is recommended (including collection of PCB data in cockles, sculpins, walruses, other marine mammals, and near-shore birds and their eggs). While many world-wide sources are responsible for PCBs in the Arctic environment, we have no data to determine if the Port Heiden marine foods have had an added impact by local contamination.
4. **Summaries or articles on other Alaska DEW-line sites to use for comparison with the Port Heiden radio relay station site.** In particular, reports of specific food chain samplings for PCBs. We provided some of the available data on what species have been found to accumulate PCBs, but each site comes with unique situations. Port Heiden-specific data is preferred.
5. **A collection/review of sediment and fish data for PCBs in lakes and rivers.** Total Aroclors or a sum of the congeners (preferred) in land and ocean subsistence food items is recommended.

Conclusions

Below we conclude on the PCB exposures related to the various source areas and according to the time in which exposures could have taken place.

The Radio Relay Station

1. Before 1990: We don't have enough data to evaluate pre-1990 PCB exposure at the Port Heiden radio relay station site. There is no information to determine the concentration of PCBs in the soils removed from the site prior to that date or if those soils were reasonably accessible. In 1999, one sample near the septic tank might have been as high as 13,100 kg/mg. Exposures to concentrations exceeding 1000 mg/kg could increase cancer risk if people were repeatedly exposed during hunting/foraging or while working in the soil. But the radio relay station area was and continues to have limited access. Thus, we expect that exposure was possible, but not likely. Table A-1 includes dose estimates using the highest (930 mg/kg) PCB measurement in a sample known to represent a surface soil.
2. Between 1990 and 2012: Because of the removals of soil and oils prior to 1990, exposure became less likely. PCB doses calculated in Appendix A (Table A-1) indicate a health concern if people contacted some "hot spot" areas on the Relay Station on a daily basis. Community members indicated that they accessed the areas primarily for viewing game during this time and soil exposure might occur a few times in a season. Thus the highest daily dose from soil would not occur more than a few times in a year; with the infrequent exposure reported by the community, we don't anticipate noncancerous or cancerous health effects from exposure to PCBs in the radio relay station soil.
3. Currently: Crowberries growing near the radio relay station antenna pads contained Aroclor 1260 concentrations close to the FDA limit for commercially sold infant or junior foods. We estimated that the potential doses for children were above the levels of ATSDR's intermediate and chronic MRLs and below the lowest effect level for animals (See Appendix B). Although we do not view eating the crowberries alone as posing any PCB-related health effects, there is a potential for additional PCB exposures from other foods. ATSDR recommends reducing the overall exposure to PCBs by avoiding plants grown near the radio relay station. Signs posted in the radio relay station area warn against eating any edible vegetation growing there.
4. Currently: The small animal doses were much lower than those for soil and berry ingestion. We anticipate no PCB-related adverse health effects from eating small animals harvested at the radio relay station site.
5. Currently: Several soil PCB results from the Foundation Cover Soils/Pad Grid 1 area of the radio relay station site exceeded 1,000mg/kg. They have not been removed as of December

2013, but they are very unlikely to have been accessed with any frequency. The highland areas of the relay station were possibly accessed in the recent past (with hot spots below 1000 mg/kg). Dose calculations (A-1) for several exposure scenarios indicate a hazard only with very frequent access; however, hunters and others visiting the elevated lands were not likely to access the hotspots with sufficient frequency to result in adverse health effects. A fence has been placed around all hot spot areas and tarps are on the hot spot soil piles preventing potential access. The planned removal of the covered soils will prevent harmful exposures in the future and further reduce the migration of PCBs to the vegetation.

On or Near the Roads

6. Recently and Currently: PCB concentrations detected in roadway samples taken from the airport to the radio relay station area show that people who use that roadway will not be exposed to harmful levels of dust-borne PCB contamination. Although the roadway is more frequently accessed than the former relay station, the samples averaged much less than the soils at the relay station (See Appendix B). In the 2013 the roadway hotspots were covered with tarps which should further reduce the chance accidental exposures. These soils are planned for removal. There is trace levels of PCBs found adjacent to these hotspots; some have suggested that this is from an old Army power plant and others suggest that was from a building used after World War II. This will be investigated further.

Elsewhere in the Environment

7. Currently: We cannot assess PCB concentration in the marine food chain exposure pathway. PCB data are unavailable for clams and walruses—subsistence food sources for residents in the Bristol Bay area near Port Heiden.

Recommendations

Although total Aroclors (only Aroclor 1260 was detected) in soil is sufficient for an estimate of PCB concentrations and to determine soil removals and areas to remediate, congener-specific data for plants and animals is preferable. In particular, congener-specific data are preferable for evaluating human health and are recommended.

We recommend filling as many data gaps as possible. Data gaps are summarized in the Data Gap section of this health consultation and some of them are more specifically defined here:

1. To minimize any additional exposure, the USAF and USACE should ensure that workers, especially local contractors, are adequately protected and educated about exposures before they handle PCB-contaminated soils.
2. The USAF, USACE[9], or U.S. EPA should sample for PCBs in the soil within the Village of Port Heiden. Potential is identifiable for the redistribution of soils from the former WACS/radio relay station, possible use of PCBs oils for dust suppression, as well as other sources.
3. The USAF or Corps of Engineers should sample the remaining roads on which PCBs might have been used for dust suppression. Testing of the borrow landfill sites (particularly drainages) and transportation routes for PCBs is recommended. Additionally, any remaining PCB hot spot areas in soil should be removed (including any associated with the old Army Power Plant, especially if access isn't restricted to people.
4. ATSDR through its memorandum of understanding could work through Superfund Community Action through Nutrition (SCAN) or a similar program to help the community improve its overall health status to include a focus on local contaminants. A program designed to identify which foods contain the highest levels of PCBs and ways of preparing food or finding substitutes that could reduce exposure is recommended.
5. Should the above studies indicate PCB exposures, further investigation of food sources should be conducted. PCB data are unavailable for clams, sculpins, walruses and other marine mammals, and other animals in the Bristol Bay area near Port Heiden near shore and marine birds and their eggs are also food sources of some of the community.
6. Sample cockles in Bristol Bay for PCBs. Such sampling is warranted due to the vicinity of the radio relay station site (within 5 km of Bristol Bay), the recently eroding landfill adjacent to the bay, and potential riverine (Reindeer and Abbott Creeks) inputs of PCBs into the bay. And most residents consume cockles. While we expect some PCBs from worldwide sources, we want to make sure that they are not unusually higher than elsewhere in the region.
7. Residents need to follow the instructions on the posted signs that advise not to collect subsistence food at the radio relay station site.
8. Residents who want to lower their PCB body burdens could limit consumption of the Arctic subsistence foods that tend to have higher PCB concentrations. Such reduction would also reduce their risk of cancer and adverse health effects, such as learning problems.

[9] Since the USACE serves in many roles in Port Heiden including lead agent for FUDS and contracting agent on behalf of the USAF our recommendations are not made to assign fault, but rather to identify the best Port Heiden source to address the current recommendation.

9. Residents could also reduce their exposure to PCBs in soil and dust by washing food, clothing, hands, and other items that have come in contact with PCBs.
10. Residents can help reduce some PCB risk by eating more fruits and vegetables.

Further Actions and Plans

The USAF plans to conduct further removals at the radio relay station (such as at the radio relay station Landfill, pad grid 1, Black Lagoon Outfall/Septic System Outfall, etc.) and along the roadway from the airport to the radio relay station area. Removal of approximately 20,000 cubic yards of PCB-contaminated soil was planned for 2013. As of December of 2013, some soils were removed, other areas were fenced, and tarps were placed over soils.

The Army Corps of Engineers began Fort Morrow investigations in 2012. A recent report found that 10 of the 13 Corps areas contained PCBs at levels below 1 mg/kg [USACE 2013].

Authors

Laura Frazier
Geologist, Environmental Health Scientist
Division of Community Health Investigations

Gregory Zarus
Atmospheric Scientist, Geophysicist
Division of Community Health Investigations

Reviewers

Charles Grosse
Environmental Health Scientist
Division of Community Health Investigations

Katherine Pugh
Environmental Health Scientist
Division of Community Health Investigations

Lynn Wilder
Associate Director of Science
Division of Community Health Investigations

Acknowledgements

Portions of the Background and Demographics sections of this health consultation were obtained from ATSDR's previous health consultation on Evaluation of Identified or Suspected Landfills and Drum and Debris Storage Areas at Port Heiden, Alaska [ATSDR 2010]. Most of the historical information and contaminant data were obtained through ADECs Contaminated Sites Database [ADEC 2008 (a-g)] and the Remedial Investigation/Feasibility Study [USAF 2006] for the site. Additionally, the 2009 excavation samplings were included [USAF 2010].

References

[ADEC] Alaska Department of Environmental Conservation. 2005. Division of Spill Prevention and Response. Contaminated Sites Program: Cleanup Chronology Report for Port Heiden - Fort Morrow FUDS, Alaska. December 16, 1985 Summary. URL: http://146.63.9.103/applications/spar/ccreports/Site_Report.aspx?Hazard_ID=73

[ADEC] Alaska Department of Environmental Conservation. 2008. Division of Spill Prevention and Response. Contaminated Sites Program: Big Mountain Radio relay station. Proposed Plan for Cleanup Action at the Former Facility Area Port Heiden radio relay station, Alaska. February 2008 Summary. URL: http://www.dec.state.ak.us/SPAR/CSP/sites/portheiden.htm#status

[ADEC] Alaska Department of Environmental Conservation. 2008a. Contaminated Sites Database: Cleanup Chronology Report for Port Heiden - Fort Morrow FUDS. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=73. publication date not listed but made available on the website in 2008.

[ADEC] Alaska Department of Environmental Conservation. 2008b.Contaminated Sites Database: Cleanup Chronology Report for Port Heiden AOC08 Landfill B (FUDS). URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=182. publication date not listed but made available on the website in 2008.

[ADEC] Alaska Department of Environmental Conservation. 2008c. Contaminated Sites Database: Cleanup Chronology Report for Port Heiden OT001 Composite Facility. former composite building. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=185. publication date not listed but made available on the website in 2008.

[ADEC] Alaska Department of Environmental Conservation. 2008d. Contaminated Sites Database. Cleanup Chronology Report for Port HeidenWP02 Black Lagoon. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=186. publication date not listed but made available on the website in 2008.

[ADEC] Alaska Department of Environmental Conservation. 2008e. Contaminated Sites Database: Cleanup Chronology Report for Port Heiden. WP03 Gray Lagoon aka AOC02. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=187. publication date not listed but made available on the website in 2008.

[ADEC] Alaska Department of Environmental Conservation. 2008f. Contaminated Sites Database.. Cleanup Chronology Report for Port Heiden SS004 Septic Tank. URL:

http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=188. publication date not listed but made available on the website in 2008.

[ADEC] Alaska Department of Environmental Conservation. 2008g. Contaminated Sites Database. Cleanup Chronology Report for Port Heiden SS006 POL Pipeline. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=179. publication date not listed but made available on the website in 2008.

[AMAP] Arctic Monitoring and Assessment Programme. 2009. Assessment 2009: Human Health in the Arctic. Oslo, Norway. Available at: http://www.amap.no/.

[ANA/ATSDR] Administration for Native Americans and Agency for Toxic Substances and Disease Registry. 2005. Native Village of Port Heiden: A compilation of health fact sheets. September 2005.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1994. Toxicological profile for chlorodibenzofurans. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2000a. Toxicological profile for polychlorinated biphenyls (update). Atlanta: US Department of Health and Human Services; November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html.

[ATSDR] Agency for Toxic Substances and Disease Registry.Health Consultation: Evaluation of Soil, Blood, and Air Data from Anniston, Alabama, Calhoun County, Alabama. 2000b. Atlanta, GA: ATSDR. 2000. Available at: http://www.atsdr.cdc.gov/hac/pha/pha.asp?docid=930&pg=0.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001a. Summary Report for the ATSDR Expert Panel Meeting on Tribal Exposures to Environmental Contaminants in Plants. Prepared by Eastern Research Group. March 23, 2001.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001b. Health Consultation (Exposure Investigation) Tanapag Village (Saipan) (aka Saipan Capacitors) Saipan, Commonwealth of the Northern Mariana Islands. EPA Facility ID: CMD982524506. April 17, 2001.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2001c. Health Consultation Exposure Investigation: "Investigation of Persistent Organic Pollutants in Reindeer on St. Lawrence Island N.E. Cape White Alice Site, St. Lawrence Island, Alaska" September 2001.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2008. ATSDR site visit to Port Heiden and meetings with Village Council, Village Elders and community members; November 11−13.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2010. Health Consultation-July Draft. Evaluation of Identified or Suspected Landfills and Drum and Debris Storage Areas at Port Heiden, Alaska.

[ATSDR] Agency for Toxic Substances and Disease Registry. (undated). Great Lakes human health research program research findings. Available at: http://www.atsdr.cdc.gov/grtlakes/research-findings.html [accessed August 2010].

[ATSDR] Agency for Toxic Substances and Disease Registry. 2011. Addendum to the toxicological profile for polychlorinated biphenyls. Atlanta: US Department of Health and Human Services; November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/pcbs_addendum.pdf

Bedard DL and May RJ. 1996. Characterization of the Polychlorinated Biphenyls in the sediments of Woods Pond: Evidence for Microbial Dechlorination of Aroclor 1260 *in Situ*. Environmental Science and Technology, Vol. 30, No. 1, 237-245, 1996.

[CFR] Code of Federal Regulations. 2009. Tolerances for polychlorinated biphenyls (PCBs). 21 CFR, Sect. 109.30 (2009). www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm : Reference available on the FDA website at www.FDA.gov.

Chao WY,. Hsu CC, Guo YL. 1997. Middle-Ear Disease in Children Exposed Prenatally to Polychlorinated Biphenyls and Polychlorinated Dibenzofurans. Archives of Environmental Health. Vol. 52, No. 4, 257-262, July/August 1997.

CoglianoVJ. 1998. Assessing the cancer risk from environmental PCBs. Environ Health Perspect Vol. 106, 317−23.

Cok I and Satiroglu MH. 2004. Polychlorinated biphenyl levels in adipose tissue of primiparous women in Turkey. Environ Inter 30;7−10.

Dewailly E, Ayotte P, Bruneau S, et al. 2000. Susceptibility to Infections and Immune Status in Inuit Infants Exposed to Organochlorines. Environ Health Perspect Vol. 108, No.3, 205-211; March.

Fernandez MF,.Kiviranta H. Molina-Molina J.M, et al. 2008. Polychlorinated biphenyls (PCBs) and hydroxyl-PCBs in adipose tissue of women in Southeast Spain. Chemosphere 71, 1196−1205.

Goni F, Lopez R, Etxeandia A, et al. 2007. High throughput method for the determination of organochlorine pesticides and polychlorinated biphenyls in human serum. J. of Chromatography B, 852, 15-21 (2007).

[IDPH] Illinois Department of Public Health. 2009. Polychlorinated Biphenyls (PCBs). Available at: http://www.idph.state.il.us/envhealth/factsheets/polychlorinatedbiphenyls.htm.

Jacobson JL, Jacobson SW, Humphrey HE. 1990a. Effects of exposure to PCBs and related compounds on growth and activity in children. Neurotoxicol Teratol 12:319-326.

Jacobson JL, Jacobson SW, Humphrey HE. 1990b. Effects of in utero exposure to polychlorinated biphenyls and related contaminants on cognitive functioning in young children. J Pediatr 116:38-45.

Jacobson JL and Jacobson SW. 1996. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. N Engl J Med 335:783−89.

[Keres] Keres Consulting, Inc. 2003. Limited Drinking Water Quality Assessment of Domestic Wells in the Native Village of Port Heiden. October 2003.

[Keres] . Keres Consulting, Inc. 2008. Fort Morrow A, B and C Draft Step I Assessment Report, Native village of Port Heiden, Alaska. Prepared for the Office of the Deputy Under Secretary of Defense, Installations and Environment. September 2008. Available at www.naets.info.

Kimbrough RD and Krouskas CA. 2003. Human Exposure to Polychlorinated Biphenyls and Health Effects. A Critical Synopsis. Toxicol Rev 22(4), 217-233, 2003.

Kimbrough RD, Doemland ML, Mandel JS. 2003. A mortality update of male and female capacitor workers exposed to polychlorinated biphenyls. J Occup Environ Med 2003; 45:271-282.

Kimbrough RD, Krouskas CA, Carson ML, Long TF, Bevan C, and Tardiff RG. 2010. Human uptake of persistent chemicals from contaminated soil: PCDD/Fs and PCBs. Regul Toxicol Pharmacol 57(1):43−54.

McCarthy JF and Spengler JD. 2010. Building Dynamics and Emissions from Polychlorinated Biphenyls and Chinese Drywall. January 12, 2010 presentation to CDC Atlanta, GA.

Native Council of Port Heiden. 2007. Letter to U.S. EPA’s Assessment and Brownfields Unit, Environmental Cleanup Office, Seattle, WA. Provided to ATSDR’s Regional office and headquarters on 4/13/2007 and 11/27/2007, respectively.

Nichols BR, Hentz KL, Aylward SM, et al. 2007. Age-specific Reference Ranges for Polychlorinated Biphenyls (PCB) Based on the NHANES 2001-2002 Survey. Journal of Toxicology and Environmental Health, Part A, 70:1873-1877, 2007.

[NIEHS[National Institute of Environmental Health Sciences. 2009a. Superfund Basic Research Program. The Impact of Obesity on PCB Toxicity. 2009 Progress Report. University of Kentucky. Available at: http://tools.niehs.nih.gov[accessed 2010 September 9].

[NIEHS] National Institute of Environmental Health Sciences. Research Brief 170. 2009b. Superfund Basic Research Program. Biomarkers to Investigate the Toxicity and Carcinogenicity of PHAHs. Release Date: 2/4/2009.

North Wind, Inc. 2012. Fort Morrow Remedial Investigation, Port Heiden, AK, "Port Heiden UFP-QAPP Body of Knowledge Evaluation." June 2012

Orloff KG, Dearwent S, Metcalf S, et al. 2003. Human exposure to polychlorinated biphenyls in a residential community. Arch Environ Contam Toxicol 44, 1125−131.

Reimer KJ, Bright DA, Dushenko WT, et al. 1993. The Environmental Impact of the DEW Line on the Canadian Arctic. Royal Roads Military College, Environmental Sciences Group, Victoria, British Columbia. Department of National Defence; February.

Rushneck DR, Beliveau A., Fowler B, et al. 2004. Concentrations of dioxin-like PCB congeners in unweathered Aroclors by HRGC/HRMS using EPA Method 1668A. Chemosphere. 54:79-87, Issue 1.

Schultz DE, Petrick G, Duinker JC. Complete characterization of polychlorinated biphenyl congeners in commercial Aroclor and Clophen Mixtures by Multidimensional Gas Chromatography—Electron Capture Detection. Environ. Sci. Technol., Vol 23, No.7, 852-859.

Shields PG. 2006.Understanding Population and Individual Risk Assessment: The Case of Polychlorinated Biphenyls. Cancer Epidemiology, Biomarkers & Prevention 2006; 15:830-839. Published on-line May 15, 2006. Accessed May 2011.

Silverstone AE, Rosenbaum PF, Weinstock RS. 2012. Polychlorinated biphenyl (PCB) exposure and diabetes: results from the Anniston Community Health Survey. Environ Health Perspect. May;120(5):727-32.

Theelan RMC, Liem AKD, Slob W, et al. 1993. Intake of 2,3,7,8 chlorine substituted dioxins, furans, and planar PCBs from food in the Netherlands: Median and distribution. Abstract. Chemosphere. Vol. 27, Issue 9, November 1993, 1625-35.

Tiedje JM. 2010. Using high throughput DNA sequencing to better characterize PCB, PAH, and dioxin biodegradation capacities in environmental matrices. Presentation given at ATSDR on 10/20/2010.

[USACE] US Army Corps of Engineers, Alaska District. 1976. Debris Removal and Cleanup Study Aleutian Islands and Lower Alaska Peninsula Alaska. p.352, October 1976.

[USACE] US Army Corps of Engineers. 1979. Alaska District. Aleutian Islands and Lower Alaska Peninsula. Debris Removal and Cleanup. Draft Environmental Impact statement. September 1979.

[USACE] US Army Corps of Engineers, 1987. Environmental Assessment: Department of Defense Environmental Restoration Account Port Heiden, Alaska, April 1987.[USACE/USAF] US Army Engineer District, Alaska/ U.S. Air Force (11th Civil Engineering Operations Squadron). 1994. Preliminary Assessment. Port Heiden radio relay station, Alaska. Prepared by CH_2M Hill Jan. 1994.

[USACE] US Army Corps of Engineers. 2013. Draft Remedial Investigation Report Fort Morrow Remedial Investigation Port Heiden, Alaska, Contract No. W911KB-11-D-0006, Delivery Order No. 0004. North Wind, Inc. February 2013.

[USAF] US Air Force (611th Civil Engineer Squadron). 1996. Final Preliminary Assessment/Site Inspection. Port Heiden Radio relay station. Prepared by EMCON Alaska, Inc.; March 1996.

[USAF] US Air Force (611th Civil Engineer Squadron). 2011.. Action Memorandum for a Time-Critical Removal Action of PCB-Contaminated Soil. Port Heiden Radio relay station. Port Heiden, Alaska (Draft) Final. Prepared by USAF; April 28.

[USAF] US Air Force (611th Civil Engineer Squadron). 2010. (Draft) Final Report, Remedy Selection and Implementation, Demolition and Debris Removal, Port Heiden Radio relay station, Port Heiden, Alaska. Prepared under project numbers TNYH20077201 & TNYH20087201. Report 57. June 2010.

[USAF] US Air Force (611th Civil Engineer Squadron). 2006. Final Remedial Investigation Feasibility Study. Port Heiden radio relay station. Port Heiden, Alaska. Volumes I through IV. Prepared by Weston Solutions, Inc; April. Available online at http://www.adminrec.com/PACAF.asp?Location=Alaska.

Appendix A. Site-specific Exposure Dose Estimates and Risk Assessment Summary

Methodology

ATSDR analyzed the weight of evidence of available toxicologic, medical, and epidemiologic health effects data to determine whether exposures might be associated with harmful health effects (noncancer and cancer). As a first step in evaluating noncancer effects, ATSDR compared estimated exposure doses to ATSDR's minimal risk level (MRL) and EPA's reference dose (RfD). Both ATSDR and EPA derived the same value for chronic oral exposure to Aroclor 1254 (2.0×10^{-5} mg/kg/day). Neither ATSDR nor EPA has developed a health guideline for Aroclor 1260. The MRL and RfD are conservative estimates of daily human exposure to a substance that are unlikely to result in noncancer effects over a specified duration. *Estimated exposure doses that are less than health guidelines were not considered to be of health concern.* To maximize human health protection, MRLs and RfDs have built-in uncertainty factors, making these values considerably lower than levels at which health effects have been observed. The result is that even if an exposure dose is higher than the MRL or RfD, it does not necessarily follow that harmful health effects will occur. It simply indicates to ATSDR that further evaluation is required before a conclusion can be drawn. This process enables ATSDR to weigh the available evidence in light of uncertainties and offer perspective on the plausibility of harmful health outcomes under site-specific conditions.

Exposure doses represent the amount of chemical a person is exposed to over time, and are expressed in milligrams per kilogram per day (mg/kg/day).

Sources for Toxicologic, Medical, and Epidemiologic Data

By Congressional mandate, ATSDR prepares toxicological profiles for hazardous substances found at contaminated sites. ATSDR's Toxicological Profile for PCBs was used to evaluate potential health effects in this health consultation [ATSDR 2000]. A ToxFAQs for PCBs is provided in Appendix E. ATSDR's toxicological profiles are available on the Internet at http://www.atsdr.cdc.gov/toxpro2.html or by contacting the National Technical Information Service (NTIS) at 1-800-553-6847.

EPA also develops health effects guidelines. These guidelines are found in EPA's Integrated Risk Information System (IRIS)—a database of human health effects that could result from exposure to various substances found in the environment. IRIS is available on the Internet at http://www.epa.gov/iris. For more information about IRIS, please call EPA's IRIS hotline at 1-301-345-2870 or e-mail at Hotline.IRIS@epamail.epa.gov.

MRLs used to screen non-cancer levels

Minimal risk levels (MRLs) are estimates of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects. Exposure to a level above a MRL does not mean that adverse health effects will occur. In general, MRLs are based on the most sensitive chemical-induced endpoint considered to be of relevance to humans. [ATSDR 2000a]. They are used as screening tools to determine if non-cancerous health effects need to be considered more thoroughly.

The chronic-duration MRL (0.00002 mg/kg/day) for the oral route is derived from an animal study that found a lowest observed adverse effect level (LOAEL) of 0.005 mg/kg/day [ATSDR 2000a]. The chronic-duration MRL derives from an animal study in which Rhesus monkeys fed as little as 0.005 mg/kg/day Aroclor 1254 in a glycerol/corn oil mixture for 23 months exhibited decreased antibody response and some mild clinical manifestations of toxicity (eyelid and toe/fingernail changes) [ATSDR 2000a]. Exposure doses at or below the MRL and RfD are not considered to be of health concern. This MRL was used to screen some potential long-term adult and child exposure doses estimated within this report.

An intermediate-duration MRL (0.00003 or 3.0E-05 mg/kg/day) for the oral route is derived from an animal study in which monkeys fed as little as 0.0075 mg/kg/day of a simulated human milk congener mixture for 20 weeks exhibited decrements in learning and neurobehavioral performance [ATSDR 2000a]. Neurobehavioral effects were observed in infant monkeys exposed to 7.5E-03 mg/kg/day [ATSDR 2000a]. This MRL was used to screen potential infant exposure doses estimated within this report.

Currently, ATSDR’s Toxicological Profile for PCBs does not list any adverse health effect levels for humans [ATSDR 2000a].

Cancer Slope Factors and Levels

The International Agency for Research on Cancer (IARC) and US EPA have classified PCBs as probably carcinogenic to humans. EPA has calculated an upper bound oral slope factor of 2 per milligram per kilogram per day (2 [mg/kg/day]-1) to be used for such exposures as food chain exposure, sediment or soil ingestion, presence of dioxin-like congeners, and early-life exposures. EPA also calculated less conservative oral slope factors for use in other situations (for example, when toxic PCB congeners make up less than 0.5% of the mixture or for more water-soluble congeners) [US EPA ND].

Studies of workers provide evidence that exposure to PCBs is associated with certain types of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate commercial PCB mixtures throughout their lives developed liver cancer. Based on the evidence for cancer in animals, the Department of Health and Human Services (DHHS) has stated that PCBs may reasonably be anticipated to be carcinogens. Cancer effect levels (CELs) reported in the literature ranged from 1.0–5.4 mg/kg/day in animals; no CELs exist for humans [ATSDR 2000a].

Site-specific Estimated Exposure Doses

Exposure doses for Aroclor 1260 in soil have been calculated for subsistence children and adults at the WACS/radio relay station site as well as short-term and long-term workers [USAF 2006, Volume II:, Table I-1, page 24 491]. We added additional dose scenarios for the purposes of this report. Summaries of the exposure doses for noncancer and cancer effects are presented in Tables A-1 and A-2 of this appendix.

Parameters used in the calculation of these exposure doses can be found in Appendix K of the RI/FS [USAF 2006, Volume II]. The equations and parameters are summarized in this appendix under the following sections: *Evaluating Incidental Ingestion, Evaluating Dermal Exposure, and Combined Ingestion and Dermal Exposure.* Although, in general, standard assumptions were made, the exposure frequencies were less than 365 days per year because they were meant to **represent hunting and foraging activities**: 270 days/year (3/4 of the year) for the current subsistence adult, future subsistence adult, and future subsistence child; and 60 days/year for the current subsistence child. Exposure duration was 6 years for a child and 24 years for an adult for a 30 year total duration. The exposure durations for a short-term and long-term worker were less than a year and 25 years, respectively [USAF 2006]. Additionally, the Aroclor 1260 concentration used for soil was the 95% Upper Confidence Limit (UCL) concentration of the arithmetic mean of the data for that specific area (FFA 1 through 4). For soil, the 95% UCL and Exposure Point Concentration (EPC) were the same. Values used for daily intake calculations for ingestion and dermal contact with soil can be found in the RI/FS, Appendix K, Tables 7-38 through 7-43. Doses were estimated for each area of the FFA in the RI/FS. For ATSDR's purposes, we are listing the doses calculated for the maximum, the arithmetic average, and the geometric mean for all of the reported "Hot Spots" in the RI/FS. A recent draft Remedial Investigation Report in ten areas outside these Hot Spot areas found no soil PCB levels above 1 mg/kg [USACE 2013]. Therefore, overall average soil dose estimates for the community are expected to be much less than those calculated.

Evaluating Incidental Ingestion

The following equation was used to estimate incidental ingestion of PCBs in soil. Where possible, ATSDR used site-specific information regarding the frequency and duration of exposures: we used concentrations and doses as reported in the 2006 RI/FS [USAF 2006]. When site-specific information was not available, ATSDR employed several conservative assumptions to estimate exposures.

$$\text{Estimated exposure dose} = \frac{C \times IR \times FI \times CF \times EF \times ED}{BW \times AT}$$

where:

C: Concentration of chemical in soil (mg/kg)

The highest soil Aroclor 1260 concentration reported in an accessible area was 930 mg/kg; the average of the "hot spot areas" was 48 mg/mg; and the geometric mean of the "hot spot areas" was 6.8 mg/kg. Most of the Aroclor 1260 measurements are approximate ("j"), including the highest values. Such data are typically biased, but provide definitive identification, and are usually reliable [USAF 2006].

IR: Ingestion rate (adult = 100 mg/day, child = 200 mg/day, short-term worker = 480 mg/day, long-term worker = 50 mg/day which are default exposure values) [ATSDR 2005, USAF 2006].

FI: Fraction ingested1% or 0.01 but 1was used
CF: Conversion Factor of 10^{-6} kg/mg; 1 mg = 10^{-6} kg

EF: Exposure frequency
Current subsistence child: 60 days/year
Future subsistence child resident: 270 days/year
Current subsistence adult: 270 days/year
Future subsistence adult resident: 270 days/year
Future short-term worker: 130 days/year
Future long-term worker: 250 days/year

ED: Exposure duration
Current subsistence child: 6 years
Future subsistence child resident: 6 years
Current subsistence adult: 24 years
Future subsistence adult resident: 24 years
Future short-term worker: 1 year
Future long-term worker: 25 years

BW: Body weight (adult = 70 kg and child = 15 kg, which are standard body weights for an average adult and children 1 through 6 years old) [ATSDR 2005, USAF 2006].

AT: Averaging time, or the period over which cumulative exposures are averaged.

Child, Adult, and Worker Cancer: 25,550 days
Child Non-cancer: 2,190 days
Adult Non-Cancer: 8,760 days
Future short-term worker, non-cancer: 365 days
Future long-term worker, non-cancer: 9,125 days

Evaluating Dermal Exposure

The following equation was used to estimate dermal exposure to PCBs in soil. Where possible, ATSDR used site-specific information regarding the frequency and duration of exposures: we used concentrations and doses as reported in the 2006 RI/FS [USAF 2006]. We also included doses calculated based on the arithmetic average and geometric mean of the concentrations of the "Hot Spots" reported in that document. When site-specific information was not available, ATSDR employed several conservative assumptions to estimate exposures. If the parameter is the same as for ingestion, the same assumptions were used as stated previously above in *Evaluating Incidental Ingestion.*

$$\text{Estimated exposure dose} = \frac{C \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

where:

- C: Concentration of chemical in soil (mg/kg)
- CF: Conversion Factor of 10^{-6} kg/mg; 1 mg = 10^{-6} kg
- SA: Skin Surface Area (USAF 2006)
  Child: 1100 cm^2/day
  Adult: 2480 cm^2/day
- AF: Adherence Factor (USAF 2006)
  Child: 0.2 mg/cm^2
  Adult: 0.07 mg/cm^2
- ABS: Dermal Absorption Factor for PCBs, unitless (0.14, which is the recommended dermal absorption fraction from soil for PCBs) [USEPA]].
- EF: Exposure frequency (same as for incidental ingestion)
- ED: Exposure duration (same as for incidental ingestion)
- BW: Body weight (adult = 70 kg and child = 15 kg, which are standard body weights for an average adult and children 1 through 6 years old) [ATSDR 2005, USAF 2006]
- AT: Averaging time, or the period over which cumulative exposures are averaged (same as for incidental ingestion)

Combined Ingestion and Dermal Exposure

To evaluate the potential combined effects from incidentally ingesting and dermally contacting contaminated soil, ATSDR summed the estimated exposure doses from the two pathways.

Estimated Ingestion Dose + Estimated Dermal Dose = Combined Dose

Evaluating the intermediate MRL

Since the intermediate MRL is based on animal studies of infant exposure to mother's milk, we need to convert the dose found in adults (mothers) to an infant's dose from the mother's milk. This is complicated as an infant's dose is multifactorial, based on its age, the ingestion rate of the mother, the fat content in milk, the number of children, the half-life of PCBs in blood, and the averaging time. Most studies appear to have one element missing in determining a link between mother's PCB exposure to her blood levels, then to a PCB concentration in her breast milk, and then to child's dose. One study of PCB and pesticide levels predicted an upper bound estimate of the relationship of between child's and mother's dose at 50 to 1 [Greizerstein et al. 1999]. A study of 24 Korean mothers exposed to PCBs and other chlorinated chemicals estimated the child to mother relationship of 20.7 to 1 for the first year [Yang et al. 2002]. Two models were developed to calculate the relationship, one based on mother/child physiology [Verner et. al. 2008, 2009] and another based on mice data for PCB-153 [Redding et al. 2008]. Both models include the data from many studies to predict each step in the exposure process. Both predict that the child's dose is between 10 and 100 times higher than the mother's dose for many PCBs. There is great variation and specific data is needed to evaluate with more precision. A study following the model development showed relationship of 38 to 1 [Alivernini et al. 2011]. We selected 40 to 1 relationship to be protective of infants.

Interpretation of Dose Estimates

Several of the estimated exposure doses[10] in Table A-1 for noncancerous effects exceeded the chronic MRL for subsistent adults, children, and workers –currently and in the future. Exposure doses estimated for subsistent children in some cases was close to or higher than the LOAEL. The MRL is a level considered to be minimal risk and the LOAEL in most cases is considered to be an unacceptable risk. Therefore, attention is given to the site exposure conditions above the MRL and particular attention for exposures close to or above the LOAEL.

The dose for the future subsistence child exceeded the LOAEL (for the arithmetic mean of the Hot Spots) because we assumed children to have more contact with the soil if the site becomes unrestricted and redeveloped. The future subsistence dose estimated using the geometric mean of the Hot Spots is higher than the chronic MRL, also due to the potential increase in access if the Hot Spots are not remediated and access increases. It is reasonable to consider the possibility of these future exposures as the village has already moved to higher inland ground due to sea level rise and because some wild food species have moved inland even farther. Since the Air Force is considering further screening and removal, these removals will reduce the chance of accessing any remaining hotspots.

The current scenario is that children are not residing on the site and remediation of the site has recently occurred and is expected to continue. Furthermore, exposure factors, such as fraction

[10] based on the maximum and arithmetic average of the "Hot Spots".

ingested, were overestimated to be protective. Therefore, the current subsistent child exposure scenario is expected to be a high estimate for actual children. The dose calculated for the geometric mean of the Hot Spot concentrations reflects a high, but possible estimate and that estimate is well below the MRL. The arithmetic mean of the hotspots is biased high and close to the MRL.

Based on the exposure doses and the assumptions used to calculate them, ATSDR does not anticipate noncancerous health effects in children, adults, or workers from current exposure to soil at the radio relay station site (under current and future conditions). However, should conditions change to permit greater access or should additional Hot Spots be identified that are closer to the community, doses could approach the LOAEL.

What could the worst case exposures be?

We do not know how high the exposure could have been in the past, prior to 1990, but we can offer a table to provide a few point estimates (A-1). A true average or upper confidence level cannot be calculated for the Port Heiden relay station site prior to 1990, as there were several soil removals prior to the collection of data for the RI/FS. While we are uncertain of the concentration, contact with the highest values was likely to be limited. It is anticipated that prior to removals, soil had higher levels of Aroclor 1260, but it is also likely that those soils were stained as they were removed based on observation. Thus, these soils are likely to be avoided by adults knowing about the site.

A few (adult) community members stated that they occasionally used the relay station property to spot caribou, as the elevated slope provided a good view. No one accessed the property with any great frequency, because it was very far from the community homes. Because the Port Heiden residents knew about the military operations and because the soils were removed based on observation (likely to be stained), we expect the hunters would have avoided contact with much of those soils. Exposure to unstained soils was also likely to be limited to possible touching, but some small amounts of unintentional soil ingestion cannot be entirely disregarded.

Without a statistically representative sampling data set, ATSDR cannot appropriately estimate past exposure. For this reason we retained the one post-removal maximum value (of 930 mg/kg) found on the accessible portion of the site to estimate a dose and compare with screening values. There was one higher measured value (13,100 mg/kg), but it was collected in a location not likely accessed (in the septic tank area). Using the maximum value to estimate chronic exposure is not a common practice, as an average more likely represents long term exposure. Using 930 mg/kg does not represent the likely exposures for current or future scenarios should clean up continue, but in the absence of data to calculate an upper confidence value prior to 1990, it does provide a possible estimate of a concentration that could be contacted unknowingly. Thus the dose associated with 930 mg/kg is retained in Tables A-1 for a few of the scenarios (discussed previously). The maximum concentration, 930 mg/kg, does not represent the likely chronic exposures for current or future scenarios and the arithmetic mean is more representative of the concentration of the contaminant that people may regularly come in contact with. Thus the arithmetic mean is used to calculate the daily human dose for comparison to the MRL in Table A-1.

Soil levels near 10 mg/kg are estimated to exceed the MRL for a current subsistent child. We learned in October of 2013 that these areas were fenced and covered with a tarp. A few samples along roads were also above 10 mg/Kg and said to be tarped along with adjacent soils areas above 1ppm. These actions are also documented in the minutes of the November remedial investigation meeting [Triad 2013].

A summary of long-term exposure doses and the associated cancer risk is provided in Table A-2. These were calculated using the arithmetic mean of the hot-spot concentrations. The highest cancer risk for the future subsistence child was 9.27E-05 (or less than 1 in 10,000). Based on these exposure doses and the assumptions used to calculate them, ATSDR does not anticipate cancerous health effects in children, adults, or workers from exposure to soil at the WACS/radio relay station site.

Table A-1. Summary of Exposure Doses for Noncancer Effects from

Category of People and Time	*Hot Spot Soil Concentration (in mg/kg)*	*Incidental Ingestion of Soil, (mg/kg/day)*	*Dermal Contact with Soil, (mg/kg/day)*	*Total (mg/kg/day)*		
				Total dose¥ Levels greater than MRL (2.0E-5) in bold	*Dose from breastmilk Levels greater than Intermediate MRL (3.0E-5) in bold€*	*Comment about LOAELs, 5.0E-3 and 7.5E-03*
Current Subsistence Child	930 * 48 ** 7 ***	2.04E-04 1.04E-04 1.48E-05	3.14 E-04 1.60E-05 2.28E-06	**2.04 E-03** **1.20 E-04** 1.71 E-05	**NA**	Soil Maximum approaches the LOAEL
Future Subsistence Child Resident	NA 48 ** 7 ***	NA 4.68E-04 6.67E-05	NA 7.21E-05 1.03E-06	NA **5.41 E-04** **7.69 E-05**	NA	Exposures below the LOAEL
Current Subsistence Adult	930 * 48 ** 7 ***	9.83E-04 5.02E-05 7.14E-06	2.39E-04 1.22E-05 1.74E-06	**1.22E-03** **6.24 E-05** 8.88 E-06	4.27 E-02 **2.18 E-03** **4.53 E-04**	Maximum mothers milk exceeded LOAEL
Future Subsistence Adult Resident	NA 48 ** 7 ***	NA 5.02E-05 7.14E-06	NA 1.22E-05 1.74E-06	NA **6.24E-05** 8.88 E-06	NA **2.18 E-03** **4.53 E-04**	Mean mothers milk approaches LOAEL
Future Short-term Worker	NA 48 ** 7 ***	NA 1.16E-04 1.65E-05	NA 5.87E-06 8.36E-07	NA 1.22E-04 1.73E-05	NA **4.80E-03** **6.64E-04**	Mean mothers milk approaches LOAEL
Future Long-term Worker	NA 48 ** 7 ***	NA 2.32E-05 3.31E-06	NA 1.13E-05 1.61E-06	NA **3.45 E-05** 4.91 E-06	NA **9.99 E-04** **2.94 E-04**	Exposures below LOAEL

*maximum concentration of Aroclor 1260 at the radio relay station landfill, FFA 2
**arithmetic mean of the 56 "hotspot area" concentrations of Aroclor 1260
*** the geometric mean of the "hot spot area" Aroclor 1260 concentrations; the dose associated with the roadway samples averaged much less than this value.
! indicates a dose that is higher than the associated LOAEL (lowest observed adverse effect level).¥Total Dose = soil ingestion and dermal dose (and does not include dose from mother's milk)

€ the does from breast milk applies to the children for each Category of People

NA means not applicable. This applies to children as they do not produce breast milk and to the future scenarios as the value now represents a value unlikely to be chronically exposed.

MRL (minimal risk level): level likely to be without an appreciable risk of deleterious effects (noncarcinogenic)
Intermediate (duration of exposure 15 to 364 days) MRL. Based on developmental neurotoxicity for PCBs. As a point of comparison: The dose for ingestion of berries was 5.51E-05 for children and 2.36E-05 for adults (provided in Appendix B).

Hot Spots.

Table A-2. Summary of Exposure Doses and Cancer Risk from Hot Spots

Category of People and time	*Incidental Ingestion of Soil (mg/kg/day) **	*Dermal Contact with Soil (mg/kg/day)**	*Theoretical Cancer Risk***
Current Subsistence Child	8.93-06	1.37E-06	2.06E-05
Future Subsistence Child Resident	4.02E-05	8.39E-06	9.27E-05
Current Subsistence Adult	1.72E-05	4.18E-06	4.28E-05
Future Subsistence Adult Resident	1.72E-05	4.18E-06	4.28E-05
Future Short-term Worker	1.66E-06	8.39E-08	3.48E-06
Future Long-term Worker	8.30E-06	4.04E-08	2.47E-05
Lifetime risk of Resident	1.00 E-04	2.44 E-05	1.25 E-04

*Values calculated assuming arithmetic mean of HOT Spots 48 mg/kg. (There are no Cancer Effect Levels for humans. The theoretical risk is based on animal studies.)

** Calculated by adding the two doses and multiplying by the cancer risk factor of 2 per mg/kg/day

For comparison: The dose (and risk) for ingestion of berries was 4.72E-06 (9.4 E-06) for children and 8.09E-06 (1.6 E-05) for adults provided in Appendix B.

The Maximum total is the total risk calculated for 70 yrs of exposure assuming hotspots were not removed.

Human Health Risk Assessment for the FFAs in the RI/FS

During the RI/FS process, US EPA conducted a Baseline Human Health Risk Assessment (BHHRA) [USAF 2006]. Their risk assessments show potential carcinogenic and non-carcinogenic risks above acceptable risk levels for soil of the Former Facility Area [ADEC 2008 (c)]. These hypothetical residential and worker scenarios are used by EPA to determine human health risk if the contamination is not cleaned up, removed, or remediated. This differs from ATSDR's procedure of estimating potential exposures, but both come to the general conclusion that people should not have regular contact with areas with the higher contamination.

Current and Future scenarios

Non-cancer risk

Under current use scenarios for soil, FFA 1, FFA2, and FFA3 had hazard indexes (HIs) greater than the non-cancer point of departure of 1. This standard measures the likelihood that a person who comes into contact with contaminants at the site over the course of a lifetime will experience non-cancer health effects. Aroclor 1260 concentrations in soil contributed over 98% of the total noncancer HI.

For future use scenarios, Aroclor 1260 also had a HI greater than 1. The non-cancer risk was greatest at FFA2 with a hazard quotient (HQ) ranging from 21 to 204.9 (child subsistence resident); Aroclor 1260 contributed approximately 99% of the entire risk across all soil exposure routes—ingestion, and dermal contact.

Area-Specific Cancer risk Estimates (from the RI/FS)

Under current use scenarios for soil, FFA1 and FFA2 had the highest carcinogenic risks for adult subsistence users at 2.8E-04 and 3.3E-04, respectively; Aroclor 1260 and benzo(a)pyrene contributed over 96% of the total cancer risk across all exposure routes [USAF 2006]. This risk was primarily due to soil ingestion and to a lesser degree to dermal contact (Dermal exposure poses lower risks because PCBs are substantially but incompletely absorbed through the skin [Cogliano 1998]). The child subsistence user followed a similar pattern. These scenarios exceeded the carcinogenic point of departure of 1 in a million (1.0E-06) excess cancers over a lifetime of exposure.

For future use scenarios, Aroclor 1260 exceeded the point of departure for all exposure scenarios and receptors associated with FFA 1 through 3, and FFA4 with the exception of the short term worker. The child subsistence resident had the highest carcinogenic risk at FFA2 of 7E-04 followed by FFA3 with a risk of 3.8E-04.

References for Appendix A

Alivernini S, Battistelli CL, Turrio-Baldassarri L. 2011. Human milk as a vector and an indicator of exposure to PCBs and PBDEs: temporal trend of samples collected in Rome. Bull Environ Contam Toxicol. 2011;87(1):21–5.

[ADEC] Alaska Department of Environmental Conservation. ND(c). Contaminated Sites Database: Cleanup Chronology Report for Port Heiden OT001 Composite Facility. former composite building. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=185

[ATSDR]. Agency for Toxic Substances and Disease Registry. 2000a. Toxicological profile for polychlorinated biphenyls (update). Atlanta: U.S. Department of Health and Human Services; November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. January 2005. Public Health Assessment Guidance Manual. Atlanta: U.S. Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/HAC/PHAManual/.

Cogliano VJ. 1998. Assessing the cancer risk from environmental PCBs. Environ.Health Perspect. 106:317-323.

Greizerstein HB, Stinson C, Mendola P, et al. 1999. Comparison of PCB congeners and pesticide levels between serum and milk from lactating women. Environ Res. 1999;80(3):280–6.

Hofe CR, Feng L, Zephyr D, Stromberg AJ, Hennig B, Gaetke LM. 2014. Fruit and vegetable intake, as reflected by serum carotenoid concentrations, predicts reduced probability of polychlorinated biphenyl-associated risk for type 2 diabetes: National Health and Nutrition Examination Survey 2003-2004. Nutr Res 34(4):285-293. doi: 10.1016/j.nutres.2014.02.001

Redding LE, Sohn MD, McKone TE, et al. 2008. Population physiologically based pharmacokinetic modeling for the human lactational transfer of PCB-153 with consideration of worldwide human biomonitoring results. Environ Health Perspect. 2008;116(12):1629–35.

Stow JP, Sova J, Reimer KJ. 2005. The relative influence of distant and local (DEW-line) PCB sources in the Canadian Arctic. Sci Total Environ 342:107−118.

[USACE] US Army Corps of Engineers. 2013Draft Remedial Investigation Report Fort Morrow Remedial Investigation Port Heiden, Alaska, Contract No. W911KB-11-D-0006, Delivery Order No. 0004. North Wind, Inc. February 2013.

[USAF] US Air Force 11th Air Control Wing 11th Civil Engineering Operations Squadron. 1994Preliminary Assessment, Port Heiden, Alaska. (page 19) January 1994.

[USAF] US Air Force (611th Civil Engineer Squadron). 2006 Final Remedial Investigation Feasibility Study. Port Heiden radio relay station. Port Heiden, Alaska. Volumes I and II. April 2006. Prepared by Weston Solutions, Inc. Available on-line at http://www.adminrec.com/PACAF.asp?Location=Alaska.

[USEPA] US Environmental Protection Agency. ND. Integrated risk information system (for polychlorinated biphenyls). URL: http://www.epa.gov/iris/subst/0294.htm Accessed August 10, 2010.

[USEPA] US Environmental Protection Agency. 2004. Risk Assessment Guidance for Superfund Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment). Final. Available at: http://www.epa.gov/oswer/riskassessment/ragse/pdf/part_e_final_revision_10-03-07.pdf.

Verner MA, Charbonneau M, Lopez-Carrillo L, et al. 2008. Physiologically based pharacokinetic modeling of persistent organic pollutants for lifetime exposure assessment: a new tool in breast cancer epidemiologic studies. Environmental Health Perspectives. 2008;116(7):886–92.

Verner MA, Ayotte P, Muckle G, et al. 2009. A physiologically based pharmacokinetic model for the assessment of infant exposure to persistent organic pollutants in epidemiologic studies. Environ Health Perspect. 2009;117(3):481–7.

Appendix B. PCB Comparison Values for Food

The Food and Drug Administration (FDA) has set residue limits (i.e., tolerances) for PCBs in various foods sold commercially for human consumption to protect consumers from harmful health effects. FDA limits include 0.2 parts per million (ppm) in infant and junior foods, 0.3 ppm in eggs, 1.5 ppm in milk and other dairy products (fat basis), 2 ppm in edible portions of fish and shellfish, and 3 ppm in poultry and red meat (fat basis) [ATSDR 2000a; CFR 2009]:

Selected portion of the CFR:

[Code of Federal Regulations]
[Title 21, Volume 2]
[Revised as of April 1, 2009]
[CITE: 21CFR109.30]

TITLE 21--FOOD AND DRUGS
CHAPTER I--FOOD AND DRUG ADMINISTRATION
DEPARTMENT OF HEALTH AND HUMAN SERVICES
SUBCHAPTER B--FOOD FOR HUMAN CONSUMPTION

PART 109 -- UNAVOIDABLE CONTAMINANTS IN FOOD FOR HUMAN CONSUMPTION AND FOOD-PACKAGING MATERIAL

Subpart B--Tolerances for Unavoidable Poisonous or Deleterious Substances

Sec. 109.30 Tolerances for polychlorinated biphenyls (PCB's).

(a) Polychlorinated biphenyls (PCB's) are toxic, industrial chemicals. Because of their widespread, uncontrolled industrial applications, PCB's have become a persistent and ubiquitous contaminant in the environment. As a result, certain foods and animal feeds, principally those of animal and marine origin, contain PCB's as unavoidable, environmental contaminants. PCB's are transmitted to the food portion (meat, milk, and eggs) of food-producing animals ingesting PCB-contaminated animal feed. In addition, a significant percentage of paper food-packaging materials contain PCB's which may migrate to the packaged food. The source of PCB's in paper food-packaging materials is primarily of certain types of carbonless copy paper (containing 3 to 5 percent PCB's) in waste paper stocks used for manufacturing recycled paper. Therefore, temporary tolerances for residues of PCB's as unavoidable environmental or industrial contaminants are established for a sufficient period of time following the effective date of this paragraph to permit the elimination of such contaminants at the earliest practicable time. For the purposes of this paragraph, the term "polychlorinated biphenyls (PCB's)" is applicable to mixtures of chlorinated biphenyl compounds, irrespective of which mixture of PCB's is present as the residue. The temporary tolerances for residues of PCB's are as follows:
(1) 1.5 parts per million in milk (fat basis).
(2) 1.5 parts per million in manufactured dairy products (fat basis).
(3) 3 parts per million in poultry (fat basis).
(4) 0.3 parts per million in eggs.
(5) 0.2 parts per million in finished animal feed for food-producing animals (except the following finished animal feeds: feed concentrates, feed supplements, and feed premixes).
(6) 2 parts per million in animal feed components of animal origin, including fishmeal and other by-products of marine origin and in finished animal feed concentrates, supplements, and premixes intended for food producing animals.
(7) 2 parts per million in fish and shellfish (edible portion). The edible portion of fish excludes head, scales, viscera, and inedible bones.
(8) 0.2 parts per million in infant and junior foods.
(9) 10 parts per million in paper food-packaging material intended for or used with human food, finished animal feed and any components intended for animal feeds. The tolerance shall not apply to paper food-packaging material

separated from the food therein by a functional barrier which is impermeable to migration of PCB's.

Food and Ingestion of PCBs

In June 1986 through May 1987, a survey of 37 households (103 people) was taken for levels of harvest and use of fish, game, and plant resources at Port Heiden [USAF 2006, Table 7-25]. An average subsistence food consumption based on the food resource was also provided [USAF 2006, Table 7-26]. According to these tables, the most consumed subsistence food (g/day) at Port Heiden was walrus followed by caribou and fish (residents are no longer consuming this amount of caribou based on a dwelling herd). Walruses are marine mammals that rely on a blubber layer for warmth; therefore, they also tend to bioaccumulate PCBs. Their main predator besides humans is the polar bear, which eats mainly young walrus. Walruses eat shellfish (clams). PCB data are unavailable for clams and walruses in the Bristol Bay area.

In addition to fish; marine mammals, waterfowl, seabird eggs, and cockles are harvested from aquatic environments. Cockles are harvested along Bristol Bay beach. Most of the bird eggs are from seagulls and terns. Waterfowl are harvested during both the spring and fall migrations. Waterfowl hunters reportedly use the wetlands and streams located within the site vicinity [USAF 1994]. According to the ADCED, approximately 17 residents hold commercial fishing permits (ADCED 2004). The estimated commercial harvest of salmon in 1992 for the Northern Alaska Peninsula Fishing Area (which included Bristol Bay and the rivers entering the bay) totaled 4,247,000 fish [USAF 1994].

Current child and adult subsistence users were assumed to be exposed from ingesting biota (i.e., berries, cockles, and small mammals) that have become contaminated (via uptake) as a result of contact with site concentrations in soil, sediment, and/or surface water. However, PCBs, including Aroclor 1260, were not considered a contaminant of potential concern for cockle and no data (except background) exist for PCBs in cockles of Bristol Bay.

The exposure route for ingestion of berries, cockles, and small mammal tissue has been evaluated for the child and adult subsistence user (current and future). The intake equation and assumptions that were used to evaluate this exposure route are presented in Tables 7-66 (berries and cockles) and 7-67 (small mammals) of Appendix K [USAF 2006, Volume II]. Ingestion rates of 11.97 grams per day (g/day), 7.16 g/day, and 2.76 g/day were used for the child subsistence user in estimating intakes from ingestion of berries, cockles, and small mammals, respectively. Ingestion rates of 23.94 g/day, 14.32 g/day, and 5.52 g/day were used for the adult subsistence user in estimating intakes from ingestion of berries, cockles, and small mammals, respectively. These ingestion rates were taken from Table 7-26 (in Appendix K) in the BHHRA.

An exposure frequency of 365 days per year was used to calculate exposure doses to current child and adult subsistent users resulting from the ingestion of subsistence foods. The harvest use rates (assumed to be ingestion of edible harvest) are presented on Table 7-26 of the RI/FS (in Appendix K) [USAF 2006]. They are representative of the mean per capita grams/day used averaged over 365 days/year.

Evaluation of PCBs in Berries

Background levels of Aroclors in berry tissue near the site ranged from 0.65 ug/kg (ppb) or 0.00065 mg/kg (ppm) Aroclor 1260 to 2.45 ppb (0.00245 ppm) Aroclor 1221 [USAF 2006, Vol. II, page 24 486].

PCBs were detected in 2 samples of black crowberries (*E. nigrum*) (4 composite samples were taken from sites across the radio relay station) near the radio relay station Antenna Pads at 0.19 and 0.069 mg/kg [USAF 2006]. The Food and Drug Administration (FDA) has set residue limits (i.e., tolerances) for PCBs in various foods to protect consumers from harmful health effects. FDA limits include 0.2 ppm in infant and junior foods [CFR 2009]. Dust contaminated with very small levels of PCBs may be found on the outer surfaces of fruits and vegetables.

The concentration of 0.069 mg/kg Aroclor 1260 was used as the Exposure Point Concentration (EPC) to calculate doses. ATSDR calculated the doses using the higher composite value of 0.19 mg/kg Aroclor 1260 as well. The doses for ingestion of berries in mg/kg/day (based on input parameters for noncancerous effects) were 1.52E-04 and 5.51E-05 for children and 6.49E-05 and 2.36E-05 for adults. The doses for ingestion of berries in mg/kg/day (based on input parameters for cancerous effects) were 1.30E-04 and 4.72E-06 for children and 2.23E-05 and 8.09E-06 for adults. Although no adverse health effects from ingestion of berries is anticipated based on these doses, it would be a good idea to avoid berries in areas of known contamination (where people are more likely to also ingest higher levels of contaminated soil), especially since the levels of PCBs from other foods is not known. Additionally, berries contained other Aroclors at higher concentrations than Aroclor 1260 as indicated by the background concentrations. Signs have been posted to warn trespassers not to collect subsistence foods from the WACS/radio relay station site.

No PCB data for Cockles (Clams) in Bristol Bay

FDA's temporary tolerance for residues of PCBs for commercial foods is 2 parts per million in fish and shellfish (edible portion). The edible portion of fish excludes head, scales, viscera, and inedible bones [CFR 2009].

The Pacific coast cockle is a mollusk that buries itself just below the substratum surface (beach sediments) and has a large digging foot to re-burrow itself if dislodged. It uses its incurrent and excurrent siphons to trap food and other particles as water passes through these structures and the gills. Rejected particles accumulate beneath the gills (inside the shell). When residents resided at Meshik, beaches along the Bristol Bay coast north of the community were popular areas for digging cockles and most households attempted to harvest this marine invertebrate [USAF 2006, Volume I].

PCBs , including Aroclor 1260, were not considered as a contaminant of potential concern in the RI/FS for cockles [USAF 2006, Volume I, Table 7-24] and no data exist for PCBs in cockles from the Bristol Bay beach. However cockle (*Clinocardium nuttalli*) tissues were analyzed for inorganic contaminants, primarily metals. Two composite analytical samples of cockles were collected from the intertidal zone in front of the beach (harvested along Bristol Bay beach) at the

Marine Terminal Area [USAF 2006, Volume I]. The two cockle tissue samples were used in evaluating potential risks from eating cockles. Additionally, background statistical calculations for PCBs were generated for the cockle generating a mean of approximately 1 µg/kg or ppb Aroclor 1260 (as well as means for the other Aroclors) [USAF 2006, Volume I]. Sampling of cockles for PCBs is recommended due to the vicinity of the WACS/radio relay station site within 5 km of Bristol Bay, the recently eroding municipal landfill adjacent to the Bay, and potential riverine (Reindeer and Abbott Creeks) inputs of PCBs into the bay.

PCBs in Small Mammals

The doses for ingestion of small mammals were less than for ingestion of soil and berries. The maximum doses estimated from the site were for the current subsistence child at FFA 3: 4.70E-06 mg/kg/day for noncancer (several orders of magnitude less than the LOAEL of 5.0E-3 for immunological effects) and 4.02E-07 mg/kg/day for cancer (many orders of magnitude less than the Range of Cancer Effect Levels (CELs) in animals of 1.0–5.4, there are no CELs for humans) [Site doses are from: USAF 2006, Tables I-9 and 10, Comparison values are explained in Appendix A of this document]. There are no comparable FDA tolerance limits for small mammals. No adverse health effects are anticipated from PCB exposure via ingestion of small mammals at the WACS/radio relay station site.

References for Appendix B

ATSDR 2000a. Agency for Toxic Substances and Disease Registry. Toxicological profile for polychlorinated biphenyls (update). Atlanta: U.S. Department of Health and Human Services; November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html.

CFR 2009. Code of Federal Regulations. Tolerances for polychlorinated biphenyls (PCBs). 21 CFR, Sect. 109.30 (2009). www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/cfrsearch.cfm : Reference available on the FDA website at www.FDA.gov.

USAF 2006. U.S. Air Force (611th Civil Engineer Squadron). Prepared by Weston Solutions, Inc. Final Remedial Investigation Feasibility Study. Port Heiden radio relay station. Port Heiden, Alaska. Volumes I through IV. April 2006. Available on-line at http://www.adminrec.com/PACAF.asp?Location=Alaska.

Appendix C. PCBs at other DEW-line Station Sites

The radio relay station at Port Heiden, Alaska was active as a Distant Early Warning line (DEW-line) radar station into the late 1970s. The radio relay station became obsolete in the 1970s and was abandoned in November 1978 [ADEC 2008 (a)]. Contamination and exposure at other DEW-line stations can provide insight into the Port Heiden radio relay station exposure scenarios. Information on Canadian DEW-line sites is provided in this appendix.

The Canadian Arctic Distant Early Warning line stations were a network of military radar installations constructed in the late 1950s to monitor Arctic airspace for Soviet attack on North America. The DEW line consisted of 63 radar stations, 42 of which were on Canadian soil [Stow et al. 2005]. In 1985, the U.S. and Canada agreed to replace the DEW-line with a new satellite-based system (the new North Warning System) and to clean up the old sites. From 1989 to 1993, environmental assessments were conducted on the 42 DEW-line stations in Canada [Poland et al. 2001]. There are 21 Distant Early Warning Line (DEW-line) radar stations in the Canadian Arctic being cleaned up (PCB contamination) by the Canadian Department of National Defence (DND) [Stow et al. 2005].

All of the active DEW line sites were remarkably similar: building trains for accommodation, storage, and radar facilities (interconnected and raised off the permafrost by means of pilings), diesel power stations which provide electricity and heat, storage facilities for petroleum, oil and lubricants (POLs), pallet lines for outdoor storage, and numerous current, and outdated communication systems. Additionally, there were, in most cases, beaching areas where supplies could be brought ashore in the summer, airstrips, sewage facilities consisting of outfalls or lagoons, and numerous waste disposal areas (dumps, landfills). Sewage was not treated at the sites; it was collected in holding tanks and discharged through pipes directly onto the tundra (in the case of outfalls) or transported by truck to pits (lagoons, sometimes called lakes). The outfall areas supported abundant vegetation. Permafrost presented unique landfilling challenges. Some landfills were located in drainage courses and material was exposed during spring runoff [Reimer et al. 1993].

PCB contamination of soil at the Canadian Arctic sites has lead primarily to local contamination [Stow et al. 2005]. Studies of the Canadian Arctic DEW-line stations describe a “halo-effect” that surrounds these sites, where there are PCBs in soil and plants from 5 to 27 km (10 km is considered a conservative average) from local sources [Macdonald et al. 2000]. Comparison of PCB congener signatures of stained areas, site background (<15 km from radar sites) and remote background (>15 to over 100 km distant) samples indicate that aerial (short-range) transport of PCBs has resulted in low-level PCB inputs to soils within a 10 to 15 km radius of the sites [Reimer et al. 1993]. The primary mechanism of transportation of contaminated soil from these stations is believed to be wind-borne particulate [Stow et al. 2005]. However, they also mention other methods of particle bound redistribution of contamination due to site disturbances: Movement of personnel and equipment through highly contaminated areas and tracking soil particles over the rest of the site. PCB soil results from 18 of the 21 sites are 1 to 590 µg/g (same as mg/kg or ppm; dw Aroclor total) with a geometric mean of 3.0 µg/g. Approximately 90% of all results were less than 10 µg/g. Outfalls and lagoons were the most heavily contaminated regions of sites [Reimer et al. 1993].

The nutrient rich outfall areas contain some of the most heavily vegetated areas at the Canadian radar sites and attracted a variety of grazing animals to the radar sites including waterfowl, Arctic hare, lemming and caribou [Reimer et al. 1993]. Landfill areas were frequently drier than the surrounding tundra and supported grass and Arctic willow. They provided grazing areas for herbivores including Arctic hare and caribou. Arctic ground squirrels were frequently observed near stations in the western Arctic.

A large volume of soil contaminated with PCBs (Aroclor 1260) was discovered at Saglek, Laborador near the Salek Polevault Station [Pier et al. 2003]. The station was operated by the U.S. Air Force. The contamination was the result of poor handling and disposal of waste transformer oil during the operation of the Station from 1953 through 1971. Three separate areas were contaminated with PCBs (*average* estimated concentrations); Antenna Hill (250 µg/g or ppm), Beach (100 µg/g), and Site Summit, the location of the radar station (75 µg/g) [Pier et al. 2003].

According to Stow et al. 2005, concentrations of Aroclor 1260 in excess of 1000 µg/g (dry weight-dw) were consistently measured at Saglek. Evidence of the Aroclor 1260 mixture was present in soil, plants, and surficial freshwater lake sediments up to 27 km from the site. The closest community to the Saglek Polevault Station, Nain, is 200 km to the south [Pier et al. 2003].

DEW line Clean-up criteria (DCC) for the Arctic Canadian soils had two tiers, DCC 1 (PCBs of 1 ppm and lead of 200 ppm) and DCC II (PCBs of 5 ppm and inorganic elements, including 500 ppm lead). Soils containing lead and/or PCBs at concentrations in excess of DCC 1, but less than DCC II, could be landfilled. If one or more substances exceeded the DCC II criteria, the soil had to be removed from contact with the Arctic ecosystem [Reimer et al. 1993].

References for Appendix C

ADEC. ND(a). Alaska Department of Environmental Conservation. Contaminated Sites Database: Cleanup Chronology Report for Port Heiden - Fort Morrow FUDS. URL: http://www.dec.state.ak.us/spar/csp/search/IC_Tracking/Site_Report.aspx?Hazard_ID=73

Macdonald et al. 2000. Macdonald, R.W., L.A. Barrie, T.F. Bidleman, et al. Contaminants in the Canadian Arctic: 5 years of progress in understanding sources, occurrence and pathways. The Science of the Total Environment 254, 93-234.

Pier et al. 2003. Pier, M.D., A. Betts-Piper, C. Knowlton, A. Zeeb and K. Reimer. Redistribution of Polychlorinated Biphenyls from a Local Point Source: Terrestrial Soil, Freshwater Sediment, and Vascular Plants as Indicators of the Halo Effect. Arctic, Antarctic, and Alpine Research Vol. 35, No. 3, 349-360.

Poland et al. 2001. Poland, J.S., S. Mitchell, and A. Rutter. Remediation of former military bases in the Canadian Arctic. Cold Regions Science and Technology. Vol. 32, 93-105.

Reimer et al. 1993. K.J. Reimer, D.A. Bright, W.T. Dushenko, S.L. Grundy, and J.S. Poland. The Environmental Impact of the DEW Line on the Canadian Arctic. Royal Roads Military College, Environmental Sciences Group, Victoria, British Columbia. Department of National Defence. February 1993.

Stow et al. 2005. Stow, J.P., J. Sova, and K.J. Reimer. The relative influence of distant and local (DEW-line) PCB sources in the Canadian Arctic. The Science of the Total Environment 342, 107-118.

Appendix D. Studies of Other Communities Exposed to PCBs

There was a significant increase in mortality from cardiovascular diseases among Swedish capacitor manufacturing workers who were exposed to PCBs for at least 5 years. An increase in cardiovascular disease was also detected in the Seveso, Italy population where an industrial accident involving PCBs occurred in 1976.

The Yu-Cheng accidental poisoning incident [oil contaminated with PCBs and polychlorinated dibenzofurans (PCDFs)] in Taiwan occurred during 1978 and 1979. Children exposed in utero and born to Yucheng mothers had reduced weight and height at birth, an excess of ectodermal defects, developmental delay, reduced scores in intelligence testing, and increased behavioral problems. Evidence of immune suppression in Yucheng victims included decreased serum immunoglobulin A (IgA) and IgM levels, and reduced rates of skin reaction to and a reduced helper/suppressor T-cell ratio. Yucheng mothers reported that their Yucheng children had an increased incidence of pneumonia and/or bronchitis during the first six months after birth. Yucheng children also had a higher incidence of middle-ear diseases than their matched controls [Chao et al. 1997]. However, PCB serum levels were not significantly different between children with and without middle-ear diseases. The exact mechanism of increased middle-ear infection in this group of children was unclear [Chao et al. 1997]. A body burden of approximately 30 ng/kg (nanograms per kilogram parts per trillion or ppt) of TCDD equivalency was found in a subgroup of the Yucheng children. Less than 30 ng/kg of TCDD equivalency was reported to produce immunologic changes in the primates [Chao et al. 1997]. The children contracted otitis media easily or had difficulty clearing the infection or effusion. Otitis-prone children who had 6 or more episodes of otitis media within the first 2 years of life had lower serum IgG, IgA, IgM and IgE antibodies against the middle ear pathogens. A deficiency of antibodies is an important determinant for the increased prevalence of otitis media and its complications. Yusho victims also had increased respiratory infection.

An association was found between the results of blood tests and blood PCB levels of chronic Yusho patients in Japan 25 years after accidental ingestion of rice-bran oil contaminated with PCBs. In the Yusho population, elevated serum levels of triglycerides and total cholesterol were significantly associated with the blood PCB levels [ATSDR 2000].

ATSDR evaluated PCBs in a Pacific fishing community in Tanapag Village on the island of Saipan, in the Commonwealth of the Northern Mariana Islands. An exposure investigation (EI) was conducted in May and June of 2000. The EI results of serum PCBs levels for children and young adults (up to age 30) showed these individuals did not have detectable levels of PCB (< 3 ppb, the detection level) (ATSDR 2001a). Tanapag residents tended to have slightly increased serum PCB levels with increasing age. Another finding for Tanapag residents was that soil and sediment did not seem to be significant contributors to serum PCB in the absence of food chain exposures (ATSDR 2001a). ATSDR evaluated land crabs and concluded that no adverse health effects were anticipated from this food source; however, recommendations to reduce exposure were made (ATSDR 2001b).

A community in Anniston, Alabama was evaluated for PCB exposure because of contamination in sediments and residential soil from a chemical company (Orloff et al. 2003). Blood PCB concentrations correlated strongly with age and length of residency in the neighborhood. However, they did not correlate with PCB concentrations in soil or house dust samples from the homes. PCBs in composite surface soil samples from 19 homes ranged from nondetected to 11.7 ppm. In adults, the blood serum PCB concentrations ranged from nondetected to 210 ppb with a mean of 14.3 ppb. In children, the blood PCB concentrations ranged from nondetected to 4.6 ppb with a mean of 0.37 ppb. Past exposures may have significantly contributed to the elevated PCB concentrations in some adult members of the community.

The Mohawk Nation at Akwesasne is located at the juncture of New York State and the Canadian Provinces of Ontario and Quebec on the St. Lawrence River (DeCaprio et al. 2005). The Akwesasme Mohawks have historically depended on fish as a major source of protein in their diet. Fishing was previously the major occupation of the community. The Mohawk Nation at Akwesasne is near a federal Superfund site and two New York State Superfund sites. Sediments in several locations downstream of these sites are highly contaminated with PCBs. PCBs and other POPs continue to accumulate in local environmental media, fish, and terrestrial wildlife. Congener-specific serum PCB data were collected during 1998-2000 for 489 women and 264 men for a total adult population of 735. Total serum PCB results in adults ranged from 0.29 to 48.32 ng/g (ppb) [fish and non-fish consumers were included; age ranged from 18 to 95 years]. The median total serum PCB level was higher in men compared to women: 3.81 versus 2.94 ng/g (ppb), respectively. Exposure, health, and clinical data have been obtained for more than 1000 Mohawk adults and children. Five congener patterns were identified using a polytopic vector analysis. One pattern observed in a limited number of Mohawks was similar to patterns for air sampled near contaminated sediment deposits and for volatilized Aroclor 1248. This pattern was thought to reflect recent inhalation exposure in these Mohawks. A second pattern was consistent with unaltered Aroclor 1254. A pattern resembling Aroclor 1262 (without labile congeners) was correlated with age and thought to represent a lifetime PCB accumulation profile. The final 2 patterns contained subsets of major persistent congeners and may reflect intermediate bioaccumulation and/or differences in individual toxicokinetics.

Generally, subsistence fishing populations have higher PCB body burdens
than those populations consuming less fish. The Ojibwe tribes of the upper Great Lakes region are and have been subsistence fishers. Their serum PCB concentrations were moderately elevated compared to other subsistence fishing populations and higher than would be expected from the general population in the late 1990s. The highest serum concentration of total PCBs was measured at 18.6 ppb; 90% of tribal participants had less than 3.8 ppb (Schaeffer et al. 2006). An association was reported between total PCBs and the self-reported chronic diseases of diabetes and immunological indicators for this tribe.

References for Appendix D

ATSDR 2000. Agency for Toxic Substances and Disease Registry. Toxicological profile for polychlorinated biphenyls (update). Atlanta: U.S. Department of Health and Human Services; November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html.ATSDR 2001a. Agency for Toxic Substances and Disease Registry. Health Consultation (Exposure Investigation) Tanapag Village (Saipan) (aka Saipan Capacitors) Saipan, Commonwealth of the Northern Mariana Islands. EPA Facility ID: CMD982524506. April 17, 2001.

ATSDR 2001b. Agency for Toxic Substances and Disease Registry. Health Consultation, Evaluation of Land Crab Contamination, Tanapag Village (Saipan) (aka Saipan Capacitors) Saipan, Commonwealth of the Northern Mariana Islands. EPA Facility ID: CMD982524506. July 16, 2001.

Chao et al. 1997. Chao, Wen-Yuan, C.-C. Hsu, and Y.L. Guo. Middle-Ear Disease in Children Exposed Prenatally to Polychlorinated Biphenyls and Polychlorinated Dibenzofurans. Archives of Environmental Health. July/August 1997 (Vol. 52, No. 4).

DeCaprio et al. 2005. DeCaprio, A.P., G.W. Johnson, A.M. Tarbell, D.O. Carpenter et al. Polychlorinated biphenyl (PCB) exposure assessment by multivariate statistical analysis of serum congener profiles in an adult Native American population. Environmental Research 98 (2005) 284-302.

Orloff et al. 2003. K.G. Orloff, S. Dearwent, S. Metcalf, S. Kathman, and W. Turner. Human Exposure to Polychlorinated Biphenyls in a Residential Community. Arch. Environ. Contam. Toxicology. 44, 1125-131, 2003.

Schaeffer et al. 2006. Schaeffer D.J., J.A. Dellinger, L.L. Needham, L.G. Hansen. Serum PCB profiles in Native Americans from Wisconsin based on region, diet, age, and gender: Implications for epidemiology studies. Science of the Total Environment 377 (2006) 74-87. Neurotoxicol. Teratol. V.18, No.3, 217-227.

Appendix E. ToxFAQs for Polychlorinated Biphenyls (PCBs)

ATSDR
AGENCY FOR TOXIC SUBSTANCES AND DISEASE REGISTRY

POLYCHLORINATED BIPHENYLS

Division of Toxicology ToxFAQs™ **February 2001**

This fact sheet answers the most frequently asked health questions (FAQs) about polychlorinated biphenyls. For more information, call the ATSDR Information Center at 1-888-422-8737. This fact sheet is one in a series of summaries about hazardous substances and their health effects. It's important you understand this information because this substance may harm you. The effects of exposure to any hazardous substance depend on the dose, the duration, how you are exposed, personal traits and habits, and whether other chemicals are present.

HIGHLIGHTS: Polychlorinated biphenyls (PCBs) are a mixture of individual chemicals which are no longer produced in the United States, but are still found in the environment. Health effects that have been associated with exposure to PCBs include acne-like skin conditions in adults and neurobehavioral and immunological changes in children. PCBs are known to cause cancer in animals. PCBs have been found in at least 500 of the 1,598 National Priorities List sites identified by the Environmental Protection Agency (EPA).

What are polychlorinated biphenyls?

Polychlorinated biphenyls are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs are either oily liquids or solids that are colorless to light yellow. Some PCBs can exist as a vapor in air. PCBs have no known smell or taste. Many commercial PCB mixtures are known in the U.S. by the trade name Aroclor.

PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they don't burn easily and are good insulators. The manufacture of PCBs was stopped in the U.S. in 1977 because of evidence they build up in the environment and can cause harmful health effects. Products made before 1977 that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.

What happens to PCBs when they enter the environment?

❑ PCBs entered the air, water, and soil during their manufacture, use, and disposal; from accidental spills and leaks during their transport; and from leaks or fires in products containing PCBs.

❑ PCBs can still be released to the environment from hazardous waste sites; illegal or improper disposal of industrial wastes and consumer products; leaks from old electrical transformers containing PCBs; and burning of some wastes in incinerators.

❑ PCBs do not readily break down in the environment and thus may remain there for very long periods of time. PCBs can travel long distances in the air and be deposited in areas far away from where they were released. In water, a small amount of PCBs may remain dissolved, but most stick to organic particles and bottom sediments. PCBs also bind strongly to soil.

❑ PCBs are taken up by small organisms and fish in water. They are also taken up by other animals that eat these aquatic animals as food. PCBs accumulate in fish and marine mammals, reaching levels that may be many thousands of times higher than in water.

How might I be exposed to PCBs?

❑ Using old fluorescent lighting fixtures and electrical devices and appliances, such as television sets and refrigerators, that were made 30 or more years ago. These items may leak small amounts of PCBs into the air when they get hot during operation, and could be a source of skin exposure.

❑ Eating contaminated food. The main dietary sources of PCBs are fish (especially sportfish caught in contaminated lakes or rivers), meat, and dairy products.

❑ Breathing air near hazardous waste sites and drinking contaminated well water.

❑ In the workplace during repair and maintenance of PCB transformers; accidents, fires or spills involving transformers, fluorescent lights, and other old electrical devices; and disposal of PCB materials.

How can PCBs affect my health?

The most commonly observed health effects in people exposed to large amounts of PCBs are skin conditions such as acne and rashes. Studies in exposed workers have shown changes in blood and urine that may indicate liver damage. PCB exposures in the general population are not likely to result in skin and liver effects. Most of the studies of health effects of PCBs in the general population examined children of mothers who were exposed to PCBs.

Animals that ate food containing large amounts of PCBs for short periods of time had mild liver damage and some died. Animals that ate smaller amounts of PCBs in food over several weeks or months developed various kinds of health effects, including anemia; acne-like skin conditions; and liver, stomach, and thyroid gland injuries. Other effects

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES, Public Health Service
Agency for Toxic Substances and Disease Registry

of PCBs in animals include changes in the immune system, behavioral alterations, and impaired reproduction. PCBs are not known to cause birth defects.

How likely are PCBs to cause cancer?

Few studies of workers indicate that PCBs were associated with certain kinds of cancer in humans, such as cancer of the liver and biliary tract. Rats that ate food containing high levels of PCBs for two years developed liver cancer. The Department of Health and Human Services (DHHS) has concluded that PCBs may reasonably be anticipated to be carcinogens. The EPA and the International Agency for Research on Cancer (IARC) have determined that PCBs are probably carcinogenic to humans.

How can PCBs affect children?

Women who were exposed to relatively high levels of PCBs in the workplace or ate large amounts of fish contaminated with PCBs had babies that weighed slightly less than babies from women who did not have these exposures. Babies born to women who ate PCB-contaminated fish also showed abnormal responses in tests of infant behavior. Some of these behaviors, such as problems with motor skills and a decrease in short-term memory, lasted for several years. Other studies suggest that the immune system was affected in children born to and nursed by mothers exposed to increased levels of PCBs. There are no reports of structural birth defects caused by exposure to PCBs or of health effects of PCBs in older children. The most likely way infants will be exposed to PCBs is from breast milk. Transplacental transfers of PCBs were also reported In most cases, the benefits of breast-feeding outweigh any risks from exposure to PCBs in mother's milk.

How can families reduce the risk of exposure to PCBs?

❑ You and your children may be exposed to PCBs by eating fish or wildlife caught from contaminated locations. Certain states, Native American tribes, and U.S. territories have issued advisories to warn people about PCB-contaminated fish and fish-eating wildlife. You can reduce your family's exposure to PCBs by obeying these advisories.

❑ Children should be told not play with old appliances, electrical equipment, or transformers, since they may contain PCBs.

❑ Children should be discouraged from playing in the dirt near hazardous waste sites and in areas where there was a transformer fire. Children should also be discouraged from eating dirt and putting dirty hands, toys or other objects in their mouths, and should wash hands frequently.

❑ If you are exposed to PCBs in the workplace it is possible to carry them home on your clothes, body, or tools. If this is the case, you should shower and change clothing before leaving work, and your work clothes should be kept separate from other clothes and laundered separately.

Is there a medical test to show whether I've been exposed to PCBs?

Tests exist to measure levels of PCBs in your blood, body fat, and breast milk, but these are not routinely conducted. Most people normally have low levels of PCBs in their body because nearly everyone has been environmentally exposed to PCBs. The tests can show if your PCB levels are elevated, which would indicate past exposure to above-normal levels of PCBs, but cannot determine when or how long you were exposed or whether you will develop health effects.

Has the federal government made recommendations to protect human health?

The EPA has set a limit of 0.0005 milligrams of PCBs per liter of drinking water (0.0005 mg/L). Discharges, spills or accidental releases of 1 pound or more of PCBs into the environment must be reported to the EPA. The Food and Drug Administration (FDA) requires that infant foods, eggs, milk and other dairy products, fish and shellfish, poultry and red meat contain no more than 0.2-3 parts of PCBs per million parts (0.2-3 ppm) of food. Many states have established fish and wildlife consumption advisories for PCBs.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 2000. Toxicological profile for polychlorinated biphenyls (PCBs). Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service.

Where can I get more information? For more information, contact the Agency for Toxic Substances and Disease Registry, Division of Toxicology, 1600 Clifton Road NE, Mailstop F-32, Atlanta, GA 30333. Phone: 1-888-422-8737, FAX: 770-488-4178. ToxFAQs™ Internet address is http://www.atsdr.cdc.gov/toxfaq.html . ATSDR can tell you where to find occupational and environmental health clinics. Their specialists can recognize, evaluate, and treat illnesses resulting from exposure to hazardous substances. You can also contact your community or state health or environmental quality department if you have any more questions or concerns.

Federal Recycling Program Printed on Recycled Paper

Appendix F. Additional Information on the Adverse Effects of PCBs

PCBs in the vapor phase are primarily the lower chlorinated, more volatile PCBs. The lower chlorinated PCBs (*ortho*-rich/*para*-poor congeners) are more readily metabolized [Schaeffer 2006]. They are active at intracellular calcium channels and tend to have greater effects on neurodevelopment and behavior. They may increase, rather than decrease, serum T4 and their metabolites have significant estrogenic activity. They do not interact with the Ah receptor. Health effects would be expected to be dissimilar and/or opposite from other congener groups such as the persistent and TCDD-like ones. Fish contain many of the non-persistent lower chlorinated PCB congeners. There may be differences in PCB profiles among subgroups of populations and among various dietary groups.

Non-cancerous effects

PCB developmental neurotoxicology

Most of what is known about the possible human health risks of PCBs comes from animal studies and accidental exposure at the workplace with high levels of these chemicals. Health effects have been observed in humans accidentally exposed to high levels of PCBs, by consumption of contaminated rice oil in Japan (1968) and Taiwan (1979), by consumption of contaminated fish, and via general environmental exposure [ATSDR 2000a]. The two mass poisonings in Japan and Taiwan lead to PCBs being characterized as neurodevelopmental toxicants [NIEHS 2009b]. Exposure to PCBs has been positively correlated with neurodevelopmental problems in children: impaired learning and memory, decreased IQ scores, decreased neuoromuscular function, and lower reading comprehension [Kim et al. 2009]. Evidence exists that children exposed to PCBs in utero (through their mother's consumption of contaminated fish) had neurobehavioral and developmental deficits [ATSDR 2000a].

PCBs may be harmful to the brain development of fetus' and neonates. PCBs alter the development and excitability of brain cells and are associated with higher rates of neurodevelopmental and behavioral disorders. Exposure to PCBs impairs cognition and behavior in children [Kim et al. 2009] and is believed to change the structure of protein targets that can contribute to neurobiological problems in humans. PCBs alter dendritic growth and /or plasticity by promoting the activity of RyR. Non-coplanar PCBs can decrease catecholamine levels in certain brain regions [Seegal in Kim et al. 2009].

For the last several decades, researchers have worked on the developmental neurotoxicity of PCBs. PCBs have been implicated in epidemiological studies as an environmental cause of diverse neurodevelopmental disorders, including learning disabilities, sensory deficits, developmental delays, and mental retardation. Some researchers associated PCBs with development problems in the 1990s [Jacobson et al. 1990a, 1990b, 1996; Rice 1997; Rice and Hayward 1999, Schantz 1996]. In the last decade since 2000, there has been additional research on the neurotoxicology of PCBs; these references are provided in the Reference section for this appendix [Golub et al. 2008, Pan, I-J et al. 2009, Sable 2009, Verner et al. 2009, Yang et al. 2009].

Cardiovascular Toxicity

There is increasing evidence that exposure to PCBs can lead to cardiovascular toxicity and atherosclerosis [Hennig et al. 2002]. Superfund chemical exposure, specifically to persistent organic pollutants like PCBs, has been linked to a heightened risk of cardiovascular disease. There was a significant increase in mortality from cardiovascular diseases among Swedish capacitor manufacturing workers who were exposed to PCBs for at least 5 years. An increase in cardiovascular disease was also detected in the Seveso, Italy population where an industrial accident involving PCBs occurred in 1976.

There is increasing evidence that exposure to PCBs can lead to cardiovascular toxicity and atherosclerosis. In vitro and in vivo evidence suggests that chronic exposure to low concentrations of coplanar PCBs promotes inflammatory diseases (Hennig et al. 2002). Coplanar PCBs (aryl hydrocarbon receptor [AhR] agonists and inducers of cytochrome P450 1A1) may potentiate the pathology of cardiovascular diseases, such as atherosclerosis. In vivo evidence suggests that binding to the AhR is critical for the proinflammatory properties of PCBs. Coplanar PCBs produce oxidative stress and an inflammatory response in vascular endothelial cells. Dysfunction of endothelial cells is an underlying cause of the initiation of cardiovascular diseases. Additionally, low-level exposure to coplanar PCBs (such as PCB-153) may contribute to the development of obesity and to obesity-associated atherosclerosis [Arsenescu et al. 2008].

Cancer Specifics

IARC and EPA consider PCBs to be probable human carcinogens. However, ATSDR's Toxicological Profile for PCBs does not list any cancer effect level for humans [ATSDR 2000a] and studies in human populations do not present strong evidence that PCBs produce cancer in humans [ATSDR 2001b].

In human and animal studies, PCBs are associated with certain kinds of cancer, such as cancer of the liver and biliary tract [ATSDR 2000a; Cogliano 1998]. Mixtures of Aroclors 1016, 1242, 1254, and 1260 have been tested in rats and found to induce liver tumors when fed to female rats. Aroclor 1260 also induced liver tumors in male rats. Several of these tumors were hepatocholangiomas, a rare biliary tract tumor seldom seen in control rats [Cogliano 1998]. According to Shields, four studies report that Aroclor 1260 induces hepatocellular carcinomas in laboratory mice and rats exposed to large doses over a lifetime [Shields 2006]. However, Shields does point out that there are many pathologic dissimilarities between experimental animal tumors induced by PCBs and human liver cancer.

A large human PCB cancer study was conducted by Kimbrough et al. [Kimbrough et al. 2003] with updated mortality of male and female capacitor workers exposed to PCBs. There were 7,075 PCB-exposed workers studied with 235, 984 person-years of observation and 1,654 deaths [Shields 2006]. The study found no associations with cancer and all cancer-combined mortality was actually decreased.

PCB congeners and breast cancer risk

Two large case-control studies have found a positive association between mono-*ortho* PCBs and breast cancer risk [Demers 2002; Aronson et al. 2000 in Demers 2002]. Studies that used the sum of all PCB congeners as the measure of exposure did not report an association with the risk of breast cancer. However, the results of a study exploring specific PCB congeners suggest that exposure to dioxin-like PCBs (specifically PCB 105, 118, and 156) increases breast cancer risk. Alternatively, the results may be explained by differences between cases and controls regarding metabolic pathways involved in the biotransformation of both mono-*ortho* PCBs and estrogens [Demers 2002]. The most abundant and persistent PCB congeners (PCBs 138, 153, and 180) [such as those found in soils at Port Heiden] were not linked to breast cancer [Demers 2002]. A review of PCB exposure and breast cancer concluded there are a sufficient number of studies to support the finding that individual congeners are not associated with breast cancer [Shields 2006].

PCBs and NHL

A significant association has been found between non-Hodgkin's lymphoma (NHL) and PCB concentrations in adipose tissue and serum in recent case-control studies [Cogliano 1998].

PCBs suppress the immune system and may be a possible mechanism for PCB-induced cancer. Immunosuppression is an established risk factor for NHL. Additionally, the results from three cohorts (in Norway and the U.S.) suggest that PCB levels in blood are associated with increased risk of NHL. The blood samples were collected in the 1970s or 1980s and tested for selected PCB congeners. The strongest trends were seen for congener 118 [Engel et al. 2006]. Congener 118 is a very minor component (0.57 % by weight of the commercial mixture) of Aroclor 1260 [Schultz et al. 1989].

References for Appendix F

Arsenescu et al. 2008. Arsenescu, V., R.I. Arsenescu, V. King, Hollie Swanson, and Lisa A. Cassis. 2008. Polychlorinated Biphenyl-77 Induces Adipocyte Differentiation and Proinflammatory Adipokines and Promotes Obesity and Atherosclerosis. Env. Health Perspect. v. 116:761-768. doi:10.1289/ehp.10554 (http://dx.doi.org/10.1289/ehp.10554)

ATSDR 2000a. Agency for Toxic Substances and Disease Registry. Toxicological profile for polychlorinated biphenyls (update). Atlanta: U.S. Department of Health and Human Services; November 2000. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp17.html.

ATSDR 2001b. Agency for Toxic Substances and Disease Registry. Health Consultation, Evaluation of Land Crab Contamination, Tanapag Village (Saipan) (aka Saipan Capacitors) Saipan, Commonwealth of the Northern Mariana Islands. EPA Facility ID: CMD982524506. July 16, 2001.

Cogliano 1998. Cogliano, V. J. Assessing the cancer risk from environmental PCBs. Environ.Health Perspect. 106:317-323.

Demers et al. 2002. Demers, Alain, Pierre Ayotte, Jacques Brisson, Sylvie Dodin, Jean Robert, and Eric Dewailly. Plasma Concentrations of Polychlorinated Biphenyls and the Risk of Breast Cancer: A Congener-specifc Analysis. Am. J of Epidemiology. Vol. 155, No.7, pages 629-635.

Engel et al. 2006. Engel, L., F. Laden, A. Anderson, L. Needham, D. Barr. et al. PCBs and Non-Hodgkin Lymphoma: Results from Three Cohorts. Epidemiology. Vol. 17(6) Suppl. November 2006. Abstract.

Golub et al. 2008. Golub, M., I. Pessah, and R. Berman. Neurobehavioral consequences of developmental PCB95 exposure in mice. Neurotoxicology and Teratology 30 (2008). NBTS32.

Hennig et al. 2002a. Hennig, B., P. Meerarani, R. Slim, M. Toborek et al. Proinflammatory Properties of Coplanar PCBs: *In Vitro* and *in Vivo* Evidence, Toxicology and Applied Pharmacology 181, 174-183 (2002).

Hennig et al. 2002b. PCB-induced oxidative stress in endothelial cells: modulation by nutrients. International Journal of Hygiene and Environmental Health 205, 95-102 (2002).

Jacobson et al. 1990a. Jacobson, J. L., Jacobson, S. W., and Humphrey, H. E. 1990. Effects of exposure to PCBs and related compounds on growth and activity in children. Neurotoxicol.Teratol. 12:319-326.

Jacobson et al. 1990b. Jacobson, J. L., Jacobson, S. W., and Humphrey, H. E. 1990. Effects of in utero exposure to polychlorinated biphenyls and related contaminants on cognitive functioning in young children. The Journal of Pediatrics. V. 116. No.1.

Jacobson et al.1996. Jacobson, J. L. and Jacobson, S. W. 9-12-1996. Intellectual impairment in children exposed to polychlorinated biphenyls in utero. N.Engl.J.Med. 335:783-789.

Kim et al. 2009. Kim, Kyung Ho, S.Y. Inan, R.F. Berman, and I.N. Pessah. Excitatory and inhibitory synaptic transmission is differentially influenced by two ortho-substituted polychlorinated biphenyls in the hippocampal slice preparation. Toxicology and Applied Pharmacology. On-line March 2009.

Kimbrough et al. 2003. Kimbrough RD, ML Doemland, and J.S. Mandel. A mortality update of male and female capacitor workers exposed to polychlorinated biphenyls. J Occup Environ Med 2003; 45:271-282.

NIEHS 2009b. Research Brief 170. Superfund Basic Research Program. Biomarkers to Investigate the Toxicity and Carcinogenicity of PHAHs. Release Date: 2/4/2009.

Pan et al. 2009. Pan, I-J , J.L. Daniels, B.D. Goldman, A.H. Herring, A.M. Siega-Riz and W.J. Rogan. Lactational Exposure to Polychlorinated Biphenyls, Dichlorodiphenyltrichloroethane, and Dichlorodiphenyldichloroethylene and Infant Neurodevelopment: An Analysis of the Pregnancy, Infection, and Nutrition Babies Study. Env. Health Perspect. V.117(3): 488-494.

Rice 1997. Rice, D.C. Effect of Postnatal Exposure to a PCB Mixture in Monkeys on Multiple Fixed Interval-Fixed Ratio Performance. Neurotoxicol. Teratol. 19, No. 6, 429-434.

Rice, D. C. and S. Hayward. 1999. Effects of Exposure to PCB 126 Throughout Gestation and Lactation on Behavior (Concurrent Random Interval-Random Interval and Progressive Ratio Performance) in Rats. Neurotoxicol. Teratol. 21, No. 6, 679-687.

Roth, P (US Air Force) Data Validation Comments to “Evaluation of PCBs Associated with the Former Radio Relay Station Area, Former Fort Morrow, Port Heiden, Alaska (February 27, 2013). US Army Public Health Command June 20, 2014.

Sable et al. 2009. Sable, H.J.K., … Developmental exposure to PCBs and/or MeHg: Effects on a differential reinforcement of low rates (DRL) operant task before and after amphetamine drug challenge. Neurotoxicol. Teratol. 31, 149-158.

Schaeffer et al. 2006. Schaeffer D.J., J.A. Dellinger, L.L. Needham, L.G. Hansen. Serum PCB profiles in Native Americans from Wisconsin based on region, diet, age, and gender: Implications for epidemiology studies. Science of the Total Environment 377 (2006) 74-87. Neurotoxicol. Teratol. Vol.18, No.3, 217-227.

Schantz 1996. Schantz, S.L. Developmental Neurotoxicity of PCBs in Humans: What Do We Know and Where Do We Go From Here?

Schultz et al. 1989. Schultz, D.E., G. Petrick, and J.C. Duinker. Complete Characterization of Polychlorinated Biphenyl Congeners in Commercial Aroclor and Clophen Mixtures by Multidimensional Gas Chromatography—Electron Capture Detection. Environ. Sci. Technol., Vol. 23, No.7, 852-859.

Shields 2006. Shields, P. G. Understanding Population and Individual Risk Assessment: The Case of Polychlorinated Biphenyls. Cancer Epidemiology, Biomarkers & Prevention 2006; 15:830-839. Published on-line May 15, 2006. Accessed May 2011.

Seegal ND (2000 or later). Seegal, R. F. The Neurotoxicological Consequences of Developmental Exposure to PCBs. Abstract. Medline.

Triad 2013. US Army Corps of Engineers, Alaska Department of Environmental Conservation, and US Air Force (Triad), Fort Morrow/Port Heiden Phase I Remedial Investigation, Meeting No. 8, November 7, 2013.

Verner et al. 2009. Verner, M-A et al. A Physiologically Based Pharmacokinetic Model for the Assessment of Infant Exposure to Persistent Organic Pollutants in Epidemiologic Studies. Env. Health Perspect. 2009 March 117(3):481-487.

Yang et al. 2009. Yang, D., Ho-Kyung Kim, A. Phimister, A.D. Bachstetter, et al. Developmental Exposure to Polychlorinated Biphenyls Interferes with Experience-Dependent Dendritic Plasticity and Ryanodine Receptor Expression in Weanling Rats. Env. Health Perspect. Vol. 117(3); Mar 2009.

Appendix G. ATSDR Glossary of Environmental Health Terms

The Agency for Toxic Substances and Disease Registry (ATSDR) is a federal public health agency with headquarters in Atlanta, Georgia, and 10 regional offices in the United States. ATSDR's mission is to serve the public by using the best science, taking responsive public health actions, and providing trusted health information to prevent harmful exposures and diseases related to toxic substances. ATSDR is not a regulatory agency, unlike the U.S. Environmental Protection Agency (EPA), which is the federal agency that develops and enforces environmental laws to protect the environment and human health. This glossary defines words used by ATSDR in communications with the public. It is not a complete dictionary of environmental health terms. If you have questions or comments, call the agency's toll-free number, 1-800-CDC-INFO (1-800-232-4636).

Absorption
The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.

Acute
Occurring over a short time [compare with chronic].

Acute exposure
Contact with a substance that occurs once or for only a short time (up to 14 days) [compare with intermediate duration exposure and chronic exposure].

Adverse health effect
A change in body function or cell structure that might lead to disease or health problems

Ambient
Surrounding (for example, ambient air).

Background level
An average or expected amount of a substance or radioactive material in a specific environment, or typical amounts of substances that occur naturally in an environment.

Bioaccumulate

The ability of an organism (plant or animal) to ingest contamination with its food as well as through direct contact and store it within the organism.

Biologic uptake
The transfer of substances from the environment to plants, animals, and humans.

Biota
Plants and animals in an environment. Some of these plants and animals might be sources of food, clothing, or medicines for people.

Body burden
The total amount of a substance in the body. Some substances build up in the body because they are stored in fat or bone or because they leave the body very slowly.

Cancer
Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk
A theoretical risk for getting cancer if exposed to a substance every day for 70 years (a lifetime exposure). The true risk might be lower.

Carcinogen
A substance that causes cancer.

Chronic
Occurring over a long time [compare with acute].

Chronic exposure
Contact with a substance that occurs over a long time (more than 1 year) [compare with acute exposure and intermediate duration exposure]

Comparison value (CV)
Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.

Completed exposure pathway [see exposure pathway].

Composite
Combining of soil samples into one sample for analysis. A building made of distinct parts.

Concentration
The amount of a substance present in a certain amount of soil, water, air, food, blood, hair, urine, breath, or any other media.

Contaminant
A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.

Dermal
Referring to the skin. For example, dermal absorption means passing through the skin.

Dermal contact
Contact with (touching) the skin [see route of exposure].

Detection limit
The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Dose
The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.

Dose-response relationship
The relationship between the amount of exposure [dose] to a substance and the resulting changes in body function or health (response).

Environmental media
Soil, water, air, biota (plants and animals), or any other parts of the environment that can contain contaminants.

Environmental media and transport mechanism
Environmental media include water, air, soil, and biota (plants and animals). Transport mechanisms move contaminants from the source to points where human exposure can occur. The environmental media and transport mechanism is the second part of an exposure pathway.

EPA
United States Environmental Protection Agency.

Epidemiology
The study of the distribution and determinants of disease or health status in a population; the study of the occurrence and causes of health effects in humans.

Exposure
Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].

Exposure assessment
The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.

Exposure pathway
The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as an abandoned business); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.

Geographic information system (GIS)
A mapping system that uses computers to collect, store, manipulate, analyze, and display data. For example, GIS can show the concentration of a contaminant within a community in relation to points of reference such as streets and homes.

Groundwater
Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].

Hazard
A source of potential harm from past, current, or future exposures.

Hazard Indices (HI)

Hazard Quotient
The hazard quotient for a chemical examines the potential for risk posed by that chemical through more than one exposure route or medium. It can be summed over several media and routes of exposure. If it exceeds unity (>1), it means the receptor may be at risk to an adverse effect from that chemical through that exposure route.

Hazardous waste
Potentially harmful substances that have been released or discarded into the environment.

Health consultation
A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health consultations are focused on a specific exposure issue. Health consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical [compare with public health assessment].

Indeterminate public health hazard
The category used in ATSDR's public health assessment documents when a professional judgment about the level of health hazard cannot be made because information critical to such a decision is lacking.

Incidence
The number of new cases of disease in a defined population over a specific time period [contrast with prevalence].

Ingestion
The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way [see route of exposure].

Inhalation
The act of breathing. A hazardous substance can enter the body this way [see route of exposure].

Intermediate duration exposure
Contact with a substance that occurs for more than 14 days and less than a year [compare with acute exposure and chronic exposure].

Intermediate MRL
(see explanation under MRL).

In vitro
In an artificial environment outside a living organism or body. For example, some toxicity testing is done on cell cultures or slices of tissue grown in the laboratory, rather than on a living animal [compare with in vivo].

In vivo
Within a living organism or body. For example, some toxicity testing is done on whole animals, such as rats or mice [compare with in vitro].

Lowest-observed-adverse-effect level (LOAEL)
The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

Metabolism
The conversion or breakdown of a substance from one form to another by a living organism.

Metabolite
Any product of metabolism.

mg/kg
Milligram per kilogram.

Migration
Moving from one location to another.

Minimal risk level (MRL)
An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period [acute (≤14 days), intermediate (15-364 days), or chronic (≥365 days)]. MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].

No apparent public health hazard
A category used in ATSDR's public health assessments for sites where human exposure to contaminated media might be occurring, might have occurred in the past, or might occur in the future, but where the exposure is not expected to cause any harmful health effects.

No-observed-adverse-effect level (NOAEL)
The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals.

No public health hazard
A category used in ATSDR's public health assessment documents for sites where people have never and will never come into contact with harmful amounts of site-related substances.

Pica
A craving to eat nonfood items, such as dirt, paint chips, and clay. Some children exhibit pica-related behavior.

Point of exposure
The place where someone can come into contact with a substance present in the environment [see exposure pathway].

Population
A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).

Prevalence
The number of existing disease cases in a defined population during a specific time period [contrast with incidence].

Prevention
Actions that reduce exposure or other risks, keep people from getting sick, or keep disease from getting worse.

Public health hazard
A category used in ATSDR's public health assessments for sites that pose a public health hazard because of long-term exposures (greater than 1 year) to sufficiently high levels of hazardous substances or radionuclides that could result in harmful health effects.

Public health hazard categories
Public health hazard categories are statements about whether people could be harmed by conditions present at the site in the past, present, or future. One or more hazard categories might be appropriate for each site. The five public health hazard categories are no public health hazard, no apparent public health hazard, indeterminate public health hazard, public health hazard, and urgent public health hazard.

Public health statement
The first chapter of an ATSDR toxicological profile. The public health statement is a summary written in words that are easy to understand. The public health statement explains how people might be exposed to a specific substance and describes the known health effects of that substance.

Public meeting
A public forum with community members for communication about a site.

Receptor population
People who could come into contact with hazardous substances [see exposure pathway].

Reference dose (RfD)
An EPA estimate, with uncertainty factors built in, of the daily lifetime dose of a substance that is unlikely to cause harm in humans.

Remedial investigation
The CERCLA process of determining the type and extent of hazardous material contamination at a site.

Risk
The probability that something will cause injury or harm.

Risk reduction
Actions that can decrease the likelihood that individuals, groups, or communities will experience disease or other health conditions.

Risk communication
The exchange of information to increase understanding of health risks.

Route of exposure
The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin [dermal contact].

Sample
A portion or piece of a whole. A selected subset of a population or subset of whatever is being studied. For example, in a study of people the sample is a number of people chosen from a larger population [see population]. An environmental sample (for example, a small amount of soil or water) might be collected to measure contamination in the environment at a specific location.

Sample size
The number of units chosen from a population or an environment.

Source of contamination
The place where a hazardous substance comes from, such as a landfill, waste pond, incinerator, storage tank, or drum. A source of contamination is the first part of an exposure pathway.

Special populations
People who might be more sensitive or susceptible to exposure to hazardous substances because of factors such as age, occupation, sex, or behaviors (for example, cigarette smoking). Children, pregnant women, and older people are often considered special populations.

Statistics
A branch of mathematics that deals with collecting, reviewing, summarizing, and interpreting data or information. Statistics are used to determine whether differences between study groups are meaningful.

Substance
A chemical.

Surface water
Water on the surface of the earth, such as in lakes, rivers, streams, ponds, and springs [compare with groundwater].

Toxic agent
Chemical or physical (for example, radiation, heat, cold, microwaves) agents that, under certain circumstances of exposure, can cause harmful effects to living organisms.

Toxicity
The ability of a substance to produce an unwanted effect when the chemical has reached a sufficient concentration at a certain site in the body.

Toxicological profile
An ATSDR document that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.

Toxicology
The study of the harmful effects of substances on humans or animals.

Uncertainty factor
Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people.

Urgent public health hazard
A category used in ATSDR's public health assessments for sites where short-term exposures (less than 1 year) to hazardous substances or conditions could result in harmful health effects that require rapid intervention.

Other glossaries and dictionaries:
Environmental Protection Agency (http://www.epa.gov/OCEPAterms/)
National Library of Medicine (NIH)
(http://www.nlm.nih.gov/medlineplus/mplusdictionary.html)