From:	Ha, Nim (HSS)
To:	scon@alaska.net
Cc:	Henry, Audra E. (ATSDR/DHAC/CAPEB); Ha, Nim (HSS)
Subject:	response to request for a copy of draft Hangar 6 health consultation
Date:	Thursday, December 02, 2010 8:49:41 AM
Attachments:	FOIA request Constantino Nov2010.pdf Ft Wainwright AK Hangar 6 Nov 26 2010 mw DRAFT.docx

Dear Mr. Constantino:

In response to your public records request dated November 22, 2010 (see attached), and pursuant to the Alaska Public Records Act (AS 40.25.110-125), please find attached a **DRAFT** version of the health consultation report titled *Chemical Exposure Incident at the Hangar 6 Construction Site, June 29th and 30th, 2006, Fort Wainwright, Alaska*.

Please recognize that as a draft document, the contents of this report could change significantly in the final version. This draft was prepared by the Alaska Department of Health and Social Services under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). As such, all health consultations must be submitted to ATSDR for their review process before it becomes a final public document. We submitted this draft to ATSDR last Friday, November 26, 2010.

Thank you for your request. Please let me know if I can be of further assistance.

Regards,

Chung Nim Ha, MPH
Acting Program Manager
Environmental Public Health Program
Section of Epidemiology
Alaska Division of Public Health
3601 C Street, Suite 540
Anchorage, AK 99503
(907) 269-8028
nim.ha@alaska.gov

Health Consultation

Chemical Exposure Incident at the Hangar 6 Construction Site, June 29th and 30th, 2006

FORT WAINWRIGHT, ALASKA

Prepared by the

Alaska Department of Health and Social Services
Division of Public Health, Epidemiology Section
Environmental Public Health Program

Under Cooperative Agreement with the

Agency for Toxic Substances and Disease Registry

SUMMARY

INTRODUCTION

At Fort Wainwright, ATSDR's top priority is to ensure that base residents, workers, and visitors have sufficient information to safeguard their health. Several workers were exposed to a chemical that was released during site construction activities on June 29th and 30th, 2006, and the workers subsequently complained of health effects following the incident. The purpose of this consultation was to evaluate environmental chemistry data and the medical records of several exposed workers to determine what the workers may have been exposed to, whether the exposure event harmed their health, and whether the site poses a current or future risk to the public.

OVERVIEW

ATSDR reached two important conclusions about the Hangar 6 site at Fort Wainwright, Alaska.

CONCLUSION 1

ATSDR concludes that digging into soils in the exclusion zone of the Hangar 6 site posed a past public health hazard to workers due to the risk of breathing an unknown chemical released from the soil. Breathing the unknown chemical for a short period of time (less than one day) harmed people's short term health.

BASIS FOR DECISION

Medical records, worker interviews and other site documents support the conclusion that multiple workers were exposed to an unknown chemical on June 29th and 30th, 2006 that harmed their short-term health. The chemical was released into the air when it was exposed during construction excavation activities.

NEXT STEPS

The area where the chemical exposure occurred during excavation activities has been permanently covered by a parking lot. This means that if any of the unknown chemical is still present in a pocket of the soil it would no longer be a public health hazard because it cannot reach people's breathing zone.

CONCLUSION 2

ATSDR concludes that breathing air at the Hangar 6 site at the present time will not harm people's health. It will continue to pose no risk to public health in the future, as long as the exclusion zone remains capped and undisturbed.

BASIS FOR DECISION

The area where the chemical exposure occurred during excavation activities has been permanently covered by a parking lot. This means that if any of the unknown chemical is still present in a pocket of the soil it would no longer be a public health hazard because it cannot reach people's breathing zone.

During environmental sampling activities that were initiated following the exposure incident in June 2006, no chemicals were found in soil, soil vapor or air at levels of health concern.

NEXT STEPS

ATSDR recommends that the permanent parking lot "cap" on the Hangar 6 exclusion zone site should not be disturbed at any time in the future without consulting environmental regulators. If excavation is ever planned for the site in the future, a protective health and safety plan should be developed and implemented that takes the potential respiratory hazards to workers into account.

FOR MORE INFORMATION

If you have questions about this report, you should contact Alaska's Environmental Public Health Program (EPHP) at (907) 269-8000. You can also call ATSDR at 1-800-CDC-INFO and ask for information about the Hangar 6 site at Fort Wainwright, Alaska.

Statement of Issues

This health consultation focuses on an incident that occurred June 29th and 30th, 2006 on a construction site at Fort Wainwright, Alaska. While excavating at the construction site known as Hangar 6, multiple workers reported being exposed to a chemical that sickened them. While some of the people reporting exposure have recovered, several workers complain of on-going chronic health effects as a result of the exposure.

At the request of multiple entities, including the injured workers, the Alaska Department of Environmental Conservation (ADEC), and the U.S. Army, the Alaska Division of Public Health (ADPH) and Agency for Toxic Substances and Disease Registry (ATSDR) have collaborated to conduct an independent investigation of the exposure incident. The purpose of this health consultation is to examine available environmental sampling data and employee medical records in an attempt to determine what the workers may have been exposed to, and whether their acute, short-term and/or long-term health symptoms may be related to chemical exposure at the site. The current and future safety of the site is also discussed.

Authority

On October 24, 2006, ADPH requested permission from ATSDR to perform an independent assessment of environmental and health data from the Hangar 6 incident On November 20, 2006, Thomas Sinks from ATSDR indicated that ATSDR would formally request funding from the Department of Defense (DOD) to conduct an evaluation of the Hangar 6 incident through the cooperative agreement program. This was necessary, because the cooperative agreement program is supported by CERCLA funds and a DOD facility health consultation was outside of this authority. At ATSDR's request, ADPH submitted a proposed scope of work, timeline and budget for the project to ATSDR on January 5, 2007. DOD subsequently approved the activity and provided funds to ATSDR for a health consultation; these funds were passed through to ADPH to conduct the assessment.

Background

Fort Wainwright is an active military installation covering approximately 915,000 acres in the Fairbanks North Star Borough, Alaska. Fort Wainwright, originally referred to as Ladd Army Airfield and Ladd Air Force Base, has been in continuous service by the military since 1938. During World War II, the installation served as a crew-transfer point in the Army Air Corps' Lend Lease program. In 1947, the newly established U.S. Air Force used the facility as a re-supply and maintenance base for the remote Distant Early Warning Sites and as an experimental station in the Arctic Ocean. In January 1961, all base operations were transferred back to the U.S. Army and the base was renamed Fort Wainwright. The primary current mission of the installation is to train U.S. Army infantry soldiers in the arctic environment, and to prepare troops for rapid deployment worldwide.

Over decades of military use, routine operations, storage practices and former waste disposal practices resulted in accidental releases of chemicals to the environment at Fort Wainwright. In August 1990, Fort Wainwright was placed on the National Priorities List because of contaminated areas on the installation. The most common contaminants at the base are volatile organic compounds, pesticides, polychlorinated biphenyls (PCBs), petroleum, oils, and lubricants. Fort Wainwright also received small quantities of radioactive tritium waste and low-level radioactive materials. A Chemical Warfare Disposal Area was located at the base of Birch Hill on base; 20 to 30 cylinders of mustard agent were buried in a trench there in 1946 or 1947. In 1966, seven cylinders and an unknown number of crates were removed from the area; subsequent activities in the 1990s documented the absence of chemical warfare materials and their breakdown products at the site (ATSDR 2003).

ATSDR has conducted a number of public health activities at Fort Wainwright over the past two decades. As part of the public health assessment process, ATSDR conducted site visits to the installation in 1991, 1998 and 200[illegible]. During the 1998 visit, ATSDR met with some of the residents of on-base and nearby off-base communities, and identified two public health concerns that were further evaluated. One individual was concerned about possible exposure to harmful levels of contaminants in lawn-irrigation water drawn from the Shannon Park Baptist Church private well, which was known to be contaminated with Volatile Organic Chemicals (VOCs). ATSDR prepared a health consultation to address the concern, and concluded that no public health hazard existed from contact with this irrigation water (ATSDR 1999a). Another community member was concerned about learning disabilities and attention deficit disorders among children attending two schools serving military families at Fort Wainwright. ATSDR prepared a letter of technical assistance to address this concern, which documented that children who attended the two schools did not suffer from a higher incidence of learning disabilities than children statewide (ATSDR 1999b). A comprehensive Public Health Assessment evaluating contaminant issues across the entire installation was published in September 2003 (ATSDR 2003).

Hangar 6 or former Building 2085 was destroyed by a fire in August of 2004. Historical records indicate that solvents associated with washing of aircraft and helicopter parts were used at the facility, in addition to typical fuels and lubricants associated with military operations (North Wind 2007). Hangar 6 was a designated Hazardous Waste Accumulation point for the maintenance of Chinook helicopters, using a Petroleum, Oil, and Lubricants (POL) shed with slated mesh fence walls and a drip pan floor (ADEC 1990). The chemical exposure incident on June 29th and 30th, 2006 occurred among workers preparing the Hangar 6 area for construction of a new hangar and parking lot in the same location.

About a week after the chemical exposure incident, Dr. Larry Harikian of the Urgent Care Center in Fairbanks became the primary care provider for the four workers who had reported to Fairbanks Memorial Hospital on June 30th, 2006. He began evaluating those four workers, as well as another employee not originally seen but deemed to be more highly exposed and symptomatic, and around 30 or more others who were sent by the employer for evaluation though either asymptomatic or mildly symptomatic. Dr. Harikian was the designated primary care provider by the Alaska National Insurance Company (ANIC), the workers compensation vehicle for Alaska.

Numerous diagnostic tests were run without revealing any common findings, and symptoms/health effects in the workers were persisting and evolving. Dr. Harikian called a consultation line to the University of Washington Medical Center in Seattle for medical toxicology expertise and began working with Dr. Thomas Martin, an Occupational Medicine physician and Medical Toxicologist. One course of action was to send the five workers with the most severe symptoms to consultants: two went to the University of Washington (Dr. Matthew Keifer, and Dr Jordan Firestone), two went to the Oregon Health and Sciences University in Portland (Dr. Melanie Sa[illegible]n and one went to the Mayo Clinic in Minnesota.

Dr. Martin also recommended that a medical panel be coordinated and convened to review the environmental sampling and clinical evaluations pertaining to the exposure incident. A panel was assembled which included the physicians involved that are named above, a medical epidemiologist and an environmental toxicologist from the Alaska Division of Public Health, a medical doctor from the US Army Center for Health Promotion and Preventive Medicine (USACHPPM), a certified industrial hygienist from the construction contractor involved, and two representatives from the US Army Corps of Engineers (USACE). ADPH is only aware of one meeting of the panel, on September 1st, 2006; they participated in that conference call. Future meetings of the panel were to be called by ADPH following their review of the environmental data. Unfortunately, ADPH's environmental review of the data did not occur in a timely enough manner to accomplish the stated goals of the medical panel, due to lack of sufficient resources.

Methods

Two reports that had previously been prepared regarding this incident were reviewed as part of this health consultation. USACHPPM prepared an occupational and environmental health risk assessment of the Hangar 6 exclusion site in April 2007 (USACHPPM 2007). The purpose of that document was to evaluate existing environmental sampling data to determine whether the site was safe for construction workers to resume limited excavation, grading and paving work at the site. It was not within the scope of the USACHPPM report to evaluate the exposure incidents of June 29th and 30th, 2006 themselves, or to evaluate the health concerns of the exposed workers from that incident. The second report evaluated was a Site Investigation and Removal Action Technical Memorandum dated September 2007, which describes environmental sampling events that occurred during the period July 2006 through September 2006 (North Wind 2007). Extensive appendices of environmental sampling data from that report formed the basis for the ADPH and ATSDR environmental data review.

In addition to these reports, information was gathered from a number of additional sources. These included:

- Participation by ADPH (Lori Verbrugge) in various site update meetings with the USACE, ADEC, the U.S. Army Dept. of Public Works, Bristol Company, USACHPPM and others, August 2006 through June 2007
- Medical Panel conference call September 1st, 2006 attended by ADPH (Verbrugge);
- Site visit by ADPH (Verbrugge) on November 7th, 2006;
- Consultation, collaboration and brainstorming with medical doctors from USACHPPM (Vivian Rush) and ATSDR (Juliana Grant and Michelle Watters);
- Interviews of five injured workers by ADPH (Verbrugge), July 2007 through April 2008;
- Individual medical records from five injured workers, dated from the period June 29th, 2006 through March 31st, 2008.

Health Records Review

Health records including clinical records, worker injury reports and the USACHPPM Health Risk Assessment (USACHPPM 2007) were reviewed in an effort to characterize the possible chemical exposure based in part on the signs and symptoms attributable to specific chemical exposures. After receiving individual worker's consent for the release of confidential medical information, the ADPH obtained medical records for five of the workers involved in the incident. For the most part, the records covered the time period between June 29, 2006 and March 31, 2008. No medical records prior to the incident were provided. Worker telephone interviews were also conducted by the ADPH in 2007 and 2008.

For the five health records reviewed, signs and symptoms were categorized for four time periods: immediate onset, acute onset (occurring within 2 weeks of exposure), short-term duration (occurring or persisting up to 3 months), and long-term duration (persisting for greater than 3 months, possibly until March 31st, 2008). In an effort to ensure the privacy of the individuals involved, this information is presented collectively or is de-identified to the extent possible.

Non-Clinical Medical Reports Review

Non-clinical documents related to symptoms and other health issues were reviewed, including findings from the Medical Panel convened for the incident and a spreadsheet of symptoms from 19 workers.

Environmental Data Review

Analytical laboratory reports for the post-incident site investigations, as listed in Appendix A, were obtained and reviewed. Quality assurance summaries were reviewed for the reports, and the data were compiled into summary tables (Appendices B – E). Detected chemicals were compared to health-based screening values established by ATSDR, the U.S. Environmental Protection Agency (EPA), or the National Institute for

Occupational Safety and Health (NIOSH) when available. The health-based screening criteria are described in Appendix F.

Comprehensive data validation, such as review of raw data and chromatograms with verification of calculations, was not within the scope of the ADPH and ATSDR review of this large data set. Reported chemical concentrations in final analytical reports were taken at face value and assumed to be accurate.

Comparison of chemical concentrations in soil and soil gas (the atmosphere present in soil pore spaces) with health-based screening criteria, as documented in Appendices C and D, was limited by the following factors:

1) Screening values were not available for many of the detected chemicals;
2) Soil samples were not collected at the time the harmful exposure occurred; they were collected weeks to months later. Twenty-six of the 3[illegible] soil samples collected on September 22- 27, 2006 were taken from the top six inches of the soil after clean fill material was added and the site was re-graded, in order to confirm that the area was clean and that it was safe to resume construction.

Screening values for contaminants in soil are usually based on a soil ingestion pathway. Screening values to evaluate an inhalation pathway from soil are only available for volatile organic chemicals (VOCs), from the USEPA. Since the relevant exposure pathway for the Hangar 6 incident was inhalation, it is most likely that a volatile chemical was the causative agent. While ATSDR soil screening values are listed in Appendix C for all available chemicals for the sake of completeness, those shown for all chemical classes except VOCs are of limited meaning since they are based on the ingestion pathway.

The soil gas evaluations in Appendix D represent an over-estimation of inhalation risk because they assume the soil gas was directly inhaled. In actuality the soil gas would likely be diluted by ambient air prior to reaching the breathing zone of workers.

It was not within the scope of work for this document to duplicate the risk assessment work performed by USACHPPM, as their report evaluated the same set of environmental data. Instead, the risk assessment methodology of USACHPPM was evaluated for appropriateness of assumptions (Appendix G), and several representative calculations were checked for accuracy. The USACHPPM risk assessment was then deemed to be well-done and valid, and the results were carried forward for further consideration from a public health perspective. Conclusions from the USACHPPM risk assessment are provided in Appendix G as a convenience to the reader who may not have access to this document.

Results and Discussion

Summary of Worker Interviews

The following summary of the events of June 29th and 30th, 2006, is gleaned from interviews with the ill workers, information provided by installation staff, company staff and regulators, and USACHPPM's report and correspondence. There is no record of personal protective equipment worn, but interviews do not indicate that respiratory or eye protection was used during the excavation.

An excavation was occurring in an open area at the Hangar 6 construction site on June 29th, 2006, in preparation for construction of a parking lot. Following sub-grading activities at least two workers observed a clay layer, approximately 4 inches deep, covering a portion of the site at the southwest side of the hangar, described by one as "an almost perfect thirty-foot circle". When a caterpillar operator dug through the clay layer he noticed a "funny odor". He began to experience headaches and nausea and after about an hour he left his caterpillar and notified his supervisor. They contacted the safety officer and the worker reported to Fairbanks Memorial Hospital. He was placed in a decontamination shower and given medicine for nausea. He went home, and reported to work the next day. Other workers mentioned during interviews that they smelled the odors on June 29th, but they did not seek medical care that day. One of the workers spent time near the dirt pile from the contaminated area doing concrete and rebar inspections and related paperwork that afternoon. In the afternoon of June 29 2006, workers also reported that they watered and compacted the soil in the same area. A dirt pile pushed up from the contaminated area was fenced off using yellow caution tape.

Work continued on June 30th outside the immediate area, but downwind of it. The original worker and three others began noting symptoms again, along with the bad, strong odor. One worker was in a ditch and was overcome when he climbed out of the ditch. Another worker was in an enclosed cab of a backhoe and was overwhelmed when he exited the cab. At least four workers reported falling to their hands and knees and vomiting involuntarily at the site that day. In addition to a dry or chalky sensation in the upper airway (mouth and throat), common symptoms included nausea and vomiting and abdominal cramping, lightheadedness or dizziness and bad headache, muscle and joint achiness and weakness, some complaint of chest tightness or cough, and some complaint of numbness in the extremities. The ill workers reported to Fairbanks Memorial Hospital, where they were decontaminated in the ambulance bay. Several of the workers stated that they waited a long time to be evaluated at the hospital, and were eventually spoken to by a doctor from the military (not from Fairbanks Memorial) and then released. Most of the workers continued to seek medical care for weeks to months following the incident, due to continuation of symptoms.

The odor detected by the workers was difficult for them to describe, even though they were experienced construction workers quite familiar with commonly-encountered odors such as petroleum, benzene and solvents. The following comments were made by workers when asked to describe the odor: "obnoxious", "never smelled anything like it", "funny", "burned nose; chalky taste on lips", "like old fuel, or rotting diesel", "pungent", and "strong".

Five of the workers continued to experience symptoms that they attribute to the exposure incident on June 29th and 30th, for months or even years following the event. Those concerns are evaluated in the "health records review" section below.

Worker interviews revealed that a field screener was not on site during the exposure incident on June 29th and 30th, 2006. The purpose of a field screener is to monitor ambient air quality for the presence of chemicals at hazardous levels while construction is in progress. The USACHPPM report indicates that a field screener was required to be physically present on the site with a Photoionization Detector (PID) if more than 6 inches of soil was being removed.

Interviews with workers and site project managers also revealed that, several weeks prior to the June 29th and 30th chemical exposure incident, an unexploded ordnance (a live mortar shell) was uncovered while digging at the Hangar 6 site. Fortunately, the area was evacuated and no one was injured. Nevertheless, it is evident that a physical hazard at the site also posed a potential risk to worker safety.

Health Records Review

<u>Incident history and symptoms</u>

Workers consistently reported a foul, nasty smelling odor at the time of the incident. Although one worker described the smell as being similar to benzene, most were unable to further describe the smell other than stating that it was not a more familiar smelling volatile chemical such as a fuel or solvent. Headache and nausea associated with dry heaves were also immediate responses. Some workers reported stomach pains and cramping and light-headedness. A dry, chalky or metallic taste, shortness of breath, eye irritation and skin irritation were various symptoms reported by several workers. Some reported more immediate onset of myalgia (pain in muscles) and arthralgia (pain in joints).

In the days following the incident, headache, light-headedness and nausea persisted in most of the workers. Vomiting or dry heaves, anorexia, stomach cramps and gastrointestinal upset were also prevalent symptoms. Most of the workers also reported paresthesia (abnormal skin sensations such as tingling) of the hands and feet and myalgia. Several reported fatigue or muscle weakness. For various workers loose bowels or bloody diarrhea, sore throat, laryngitis, difficulty concentrating or short term memory loss and hematuria (blood in the urine) were reported.

The most common symptoms that persisted during the first few months for the five workers were fatigue (n=4), headache, nausea, and paresthesia of the hands and feet (n=3), and light-headedness (n=2). Most workers were reporting gradual improvement in either the frequency or intensity of the symptoms. Through the end of the first 3 months, various workers reported on-going difficulty with balance or dizziness, laryngitis, and shortness of breath.

Of the few medical records available for workers beyond 3 months post-incident, continued nausea, light-headedness, dizziness and paresthesia of the hands and feet were reported by two workers and headaches by three workers. Other long-term symptoms reported by one worker included difficulty concentrating and memory loss.

Physical exam findings

The four workers brought to the emergency room after the chemical exposure on June 30th were decontaminated by showering and provided hospital gowns to wear prior to being examined. In general, there were few positive physical findings reported. Vital signs were normal (pulse rate, respiratory rate, temperature and blood pressure). All had a percent oxygen saturation 96% or greater. With the exception that for three of the four workers a slight conjunctival injection (bloodshot eyes) was noted, the head and neck exam was normal. No miosis (constricted pupils) was reported. There was no abnormal cardiovascular, respiratory, gastrointestinal, or urinary system findings noted. For each worker, no abnormalities of the neurological exam were found including gross exam of cranial nerves II-XII, motor function and strength, reflexes, gait, coordination, and sensation. There were no acute dermatological conditions reported.

One of the workers had visited the emergency room on June 29th for a similar work exposure. With the exception of an elevated blood pressure on that day, the physical exam was normal. Another of the four workers returned to the emergency room on July 1st, 2006. His physical exam was within normal limits.

Medical records for clinic visits for all five of the workers were reviewed for pertinent physical exam findings for 3 months following the chemical exposure. During this period, a few physical exam findings were noted that were consistent with self-limited conditions including upper respiratory infections or with pre-existing chronic conditions such as hypertension. Large tonsils were noted on one workers head and neck exam. Three workers had various dermatological findings noted. One worker had a dry scaly patch on the chest and a dry lesion on an upper eyelid, and another had an erythematous (red) patch on the top of the head. A third worker had a small open lesion with crusting on the skin on the chin with subsequent exams reporting hypopigmented areas on the chin and ankle suggesting previous vesicles (very small blisters). One individual had right upper quadrant tenderness noted on two exams. Poor coordination, difficulty with balance, loss of two point discrimination (a neurological test for sensation), slight tremor, lid lag, and decreased grip strength were the abnormal neurological physical exam findings reported for three of the five workers, although there were no findings common among the workers.

There were several medical records provided for 4 of the workers for periods greater than 3 months post-exposure. Many of these were from specialists, therapists, and independent medical evaluators. Positive Tinel's and Phelan's tests (exam tests for the median nerve) were noted for an individual who was diagnosed with carpal tunnel syndrome. A decreased response to pinprick, temperature and proprioception (position sense) was reported for another worker.

Weight was recorded for four workers, beginning 1 week or more post exposure. All four of these workers weighed over 200 pounds. One was noted as being obese. Over the period the medical records covered, one worker remained within 5% of his average weight, one worker gained twenty pounds over five months, and one gained 15 pounds in one week from his first measurement and remained the same weight in subsequent follow-ups. One worker had a precipitous drop of approximately 25 pounds between the second and third month post-exposure.

<u>Laboratory findings</u>
Results from general laboratory analyses including complete blood count, comprehensive metabolic panel (electrolytes, hepatic function, renal function), and urinalysis were provided for the workers during various medical visits over the first [illegible] months post exposure. All the results were either within or close to the normal laboratory reference range. The values that were slightly above the reference range were consistent with use of prescribed medication or acute self-limited illnesses.

Several blood and urine laboratory analyses were performed for specific chemicals. However, because these chemicals have short biological half-lifes, these samples were not collected close enough to the time of the actual exposure incident in order to be useful in understanding what chemical the worker might have been exposed to for an acute one-time exposure. Therefore, non-detects or normal values would indicate that the worker was either never exposed or is no longer being exposed to that chemical.

One week post exposure, laboratory results for a blood xylene exposure profile (o-xylene, m-xylene, p-xylene, 2-methylhippuric acid, 3-+4-methylhippuric acid, and total methylhippuric acids) were provided for [illegible] of the workers. All results were non-detect for these measures. Because of the short half life of xylene in the blood, a blood xylene exposure profile must be performed within hours of exposure.

Six weeks post exposure, one worker had plasma and RBC cholinesterase levels analyzed. Typically, the duration of a depression of RBC cholinesterase is a few days to a few weeks. The results were within the normal reference range and no prior analyses were provided (for this worker) for comparison.

Six to 10 weeks post exposure, two of the workers had 24 hour urine testing for four heavy metals (arsenic, lead, mercury, and cadmium). For these metals, urine samples should be taken at least within a few days of an acute exposure. All results were reported as either non-detect or below the background reference range. One worker had a 24 hour urine total arsenic specimen submitted 4 months post exposure, this result was also below background.

Imaging studies

All 5 workers had at least one chest x-ray within the first 2 months post-exposure. Two were noted to be unremarkable or normal. Three workers had follow-up computed tomography (CT) of the chest based on the chest x-ray. Two of the worker's CT results did not suggest any acute abnormalities or process. The third worker's follow-up CT suggested small airway inflammation that may be related to acute/subacute hypersensitivity pneumonitis or inhalational insult.

Other imaging performed between the second and third post exposure month on one or two of the workers included CT of the abdomen, ultrasound of the abdomen and magnetic resonance imaging of the head. All of these imaging results were reported as being within normal limits.

Other testing

One month or more post exposure, pulmonary function testing was performed on all of the workers. With few exceptions, the results were within normal limits. A series of pulmonary function testing on one worker demonstrated a mild restrictive pattern, normal results, and a mild obstructive pattern. One worker's results showed a mild reversible small airway disease; his follow-up testing was normal.

A couple of workers had nerve conduction and electromyography of their extremities performed. One worker was identified as having median nerve neuropathy and diagnosed with carpal tunnel syndrome. The other did not show any electophysiologic evidence of any neuropathy, radiculopathy or myopathy.

Neuropsychiatric and speech evaluations were performed on two workers several months after the exposure. Impressions included: functioning was within expected and normal range across all domains assessed, reduction in visual processing abilities, anxiety, depression, mild cognitive difficulties, impairments in basic reasoning, mild to moderate cognitive linguistic deficit. One worker had an electroencephalogram reported as within normal limits.

There were ear, nose and throat referrals for several workers. One month post exposure, flexible fiberoptic laryngoscopy was performed for a worker. The impression was laryngitis secondary to chemical exposure by history. Several months post exposure, two workers received vestibular nystagmograms (a test for inner ear problems on equilibrium) and audiometric evaluations. Impressions from these tests included a possible left peripheral vestibular lesion, bilateral vestibular deficits, sensorineural hearing loss and mixed type hearing loss. No pre-exposure audiometric evaluations were available for comparison. One worker had a physical therapy evaluation that supported the impression of the balance and vestibular (related to the sense of equilibrium) problems.

Gastrointestinal evaluation carried out three months post exposure on two workers included a gastric emptying study that revealed rapid gastric emptying, a small bowel biopsy that was normal, a stomach biopsy that suggested reactive gastropathy, and a colonscopy in which a hyperplastic polyp was removed.

Non-clinical Medical Reports Review

A spreadsheet report was prepared by an Army contractor that provided information on symptoms experienced on either June 29th or 30th, 2006 for 19 workers who were all in relatively close proximity to the site of the reported incident on one or both of those two dates. For each worker, their general state of health was reported weekly for 7 weeks. There was no information reported for two of the 19 workers. Reports for the 5 workers whose medical records were reviewed above were also included in this spreadsheet. The spreadsheet on health status and reported symptoms for these 17 workers was reviewed for this health consultation.

Nausea was reported by 12 of 17 workers. Metallic taste and dizziness was also commonly described. Excluding the five workers previously discussed, there was one report of diarrhea, two of lethargy and one of respiratory effects and numbness or tingling. The recorded health condition, when available for the workers not included in the medical record review, was either fair or good for the 7 weeks of reporting.

A teleconference was organized by USACHPPM on September 1, 2006 for the health care providers involved in the case, ADPH and USACHPPM. The objectives of the call included an attempt to reach a consensus as to the causation of the illnesses or to provide a list of likely causes. The preliminary conclusions of the group were that an acute chemical exposure resulting in the initial symptoms and health effects had occurred. No objective set of findings were present to make conclusions on chronic health effects, and the identity of the causative chemical was not determined.

Environmental Data Review

Many chemicals were tested for but not detected in any environmental matrix (Appendix B). Those chemicals can effectively be ruled out as potential causative agents. These include a broad range of organophosphate pesticides and a broad range of chlorinated herbicides. Several chemical warfare agents and/or their breakdown products were tested for and not detected, including isocyanates, lewisite, HD (distilled mustard), and the mustard breakdown products 1,4-dithiane and 1,4-thioxane. Although many volatile organic chemicals (VOCs) and semivolatile organic chemicals (SVOCs) were detected in various environmental matrices (Appendices C - E), some other VOCs and SVOCs were not detected in any samples (Appendix B).

ATSDR evaluated the health risks associated with non-VOC chemicals in soil (via the incidental soil ingestion pathway) by comparing the maximum soil value found for each chemical in any soil sample to available health-based screening values (Appendix C). Levels of measured chemicals were orders of magnitude below health-based screening values, for each detected non-VOC chemical for which a screening value was available. While some inorganic chemicals did not have health-based screening values available (calcium, iron, magnesium, nickel, potassium and sodium), these are all common components of the human diet and not credible contaminants of concern. Screening values could also not be located for some individual chlorinated pesticides (delta-BHC, individual DDD and DDE congeners, endrin aldehyde and endrin ketone), but these chemicals were only present in soil at low parts-per-billion levels, and thus were not of health concern. There were also some SVOCs for which screening values were unavailable, but none of those chemicals were present above the reporting limit.

The detected chemicals of greatest potential health concern (based on concentrations detected) were the VOCs in soil gas. The only chemical/matrix combinations that exceeded a health-based screening value were several VOCs in soil gas. Evaluation of VOCs directly in soil gas is a conservative, worst-case over-estimate of risk, because chemicals in soil gas would be diluted by ambient air before reaching the worker's breathing zone. Following is a short discussion of each chemical that exceeded a health-based screening value in at least one soil gas sample.

Benzene

The highest concentration of benzene measured in soil gas was 180 µg/m^3, which exceeds to acute ATSDR EMEG of 30 µg/m^3 by six-fold. This acute inhalation standard is based on effects of benzene on the white blood cells of mice in short-term experiments, including depressed peripheral lymphocytes and mitogen-induced blastogenesis of femoral B-lymphocytes (ATSDR 2007a). Short-term exposure to very high levels of benzene in air (700-3,000 ppm) can cause drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness (ATSDR 2007a).

It is unlikely that benzene was the causative agent of the worker's signs and symptoms, for at least three reasons. Firstly, the maximum level of benzene detected in soil gas is over 1000-times lower than the concentrations that cause overt acute effects in humans such as dizziness. Secondly, the symptoms in the workers, including gastrointestinal upset and neurological sequelae do not match well with benzene toxicity. Thirdly, benzene is a common chemical and a constituent of gasoline. Its sweet smell is easily recognizable, particularly by seasoned construction workers.

Xylenes

The highest total xylene value measured in soil gas was 23,500 µg/m^3 (calculated by summing m,p-xylene at 16,000 µg/m^3, and o-xylene at 7,500 µg/m^3; both values were estimates because the reported values were above the analytical linear range). This concentration exceeds ATSDR's acute MRL for xylenes of 9,000 µg/m^3 by over two-fold. ATSDR's MRL is based on a study of health adult volunteers, who experienced a slightly reduced forced vital capacity, increased subjective respiratory effects, and increased subjective central nervous system effects (feeling of intoxication, dizziness, headache, and fatigue) at 50 ppm, which corresponds to 217,137 µg/m^3 m-xylene (ATSDR 2007b). The magnitude of the changes observed at this dose was small. OSHA has established an exposure limit of 100 ppm of xylene averaged over a workday for occupational exposures. The maximum concentraton of xylenes found in soil gas were more than 18 times lower than that workplace standard.

It is unlikely that xylenes were the causative agent of the worker's signs and symptoms, for at least two reasons. Firstly, the maximum level of xylenes detected in soil gas was far lower than the concentrations that have caused acute health effects in humans. Secondly, xylenes are common chemicals with a sweet smell that is easily recognizable, particularly by seasoned construction workers.

1,3-Butadiene

The maximum level of 1,3-butadiene that was detected in soil gas was 290 µg/m^3. That is slightly higher than ATSDR's acute inhalation MRL of 221 µg/m^3. The acute MRL was based on a study of 1,3-butadiene exposures among pregnant mice during gestation days 6–15, with the most sensitive toxic endpoint being a 5% reduction of bodyweight in male fetuses at an adjusted LOAEL of 10 ppm (22,123 µg/m^3) (ATSDR 2010a). That health outcome is not relevant for the male construction workers who were potentially exposed to 1,3-butadiene at Hangar 6.

1,4-Dichlorobenzene

The maximum level of 1,4-dichlorobenzene (1,4-DCB) detected in soil gas was 180 µg/m^3 (an estimated result because the reported value was above the analytical linear range). This estimated value is three times higher than ATSDR's chronic EMEG of 60 µg/m^3 for 1,4-DCB (ATSDR 2006). That comparison value was based on increased incidences of nasal lesions in female rats exposed to 1,4-DCB by inhalation for a period of 2 years. This chronic exposure scenario is not similar to the Hangar 6 incident, which occurred over a short duration (2 days).

The maximum level of 1,4-DCB observed in soil gas was far below ATSDR's EMEG for acute inhalation exposures of 10,000 µg/m^3; the health endpoint for that evaluation was eye and nose irritation in occupationally-exposed individuals.

Toluene

The maximum level of toluene detected in soil gas was 1,500 µg/m^3 (an estimated result because the reported value was above the analytical linear range). This estimated value is five times higher than ATSDR's chronic EMEG of 300 µg/m^3 (ATSDR 2000). That comparison value was based on a health endpoint of color vision impairment among chronically-exposed workers. This chronic exposure scenario is not similar to the Hangar 6 incident, which occurred over a short duration (2 days).

The maximum level of toluene observed in soil gas was lower than 4,000 µg/m^3, ATSDR's EMEG for acute exposures. This value was based on a controlled exposure experiment with young healthy male subjects; the effects they experienced at the highest dosage tested (380,000 µg/m^3) included irritation of the eyes and nose, as well as headaches, dizziness, and feelings of intoxication. No adverse effects were reported at the next lowest exposure level, which was 152,000 µg/m^3 toluene.

4-Methyl-2-Pentanone (AKA Methyl Isobutyl Ketone)

The maximum level of 4-methyl-2-pentanone (also known as methyl isobutyl ketone, or MIBK) observed in soil gas was 3,200 µg/m^3 (an estimated result because the reported value was above the analytical range). This estimated value is slightly higher than the USEPA's reference concentration for chronic inhalation exposures of 3,000 µg/m^3 MIBK

(USEPA 2003). The most sensitive health endpoint used to derive that comparison value was adverse developmental outcomes among fetuses born to exposed pregnant rats. That health outcome is not relevant for the male construction workers who were potentially exposed to MIBK at Hangar 6. Workers exposed to much higher levels of MIBK have reported headaches, dizziness, nausea, and throat irritation that resolved soon after removal from exposure.

Carbon Disulfide

Carbon disulfide was detected in soil gas at a maximum concentration of 45 $\mu g/m^3$ but was not detected in the soil. ATSDR's chronic EMEG for carbon disulfide is 900 $\mu g/m^3$. Acute exposure to high concentrations of carbon disulfide can result in dizziness, headache, dyspnea, nausea, vomiting, muscle weakness, fatigue, memory impairment, emotional lability, and anorexia. It is irritating to the eyes, skin, and mucous membranes (ATSDR 2010b). Chronic exposure in workers has been associated with polyneuropathy and vestibular and hearing problems.

Carbon disulfide is used as a solvent and fumigant. When pure, it is a colorless liquid with an ether smell. In commercial grade products it is a yellowish liquid with a foul odor like that of rotting radishes. Carbon disulfide readily evaporates when released to the environment, but initially stays close to the ground because it is heavier than air. It does not bind to soil and moves quickly through soil into groundwater. Because of its high mobilitiy in soil, it makes it less likely that a pool of carbon disulfide remained from the 2004 Hangar 6 fire and subsequent building demolition.

Other chemicals

Several additional chemicals were detected in at least one soil gas at concentrations similar to the chemicals discussed above. Health-based screening values were not available from either ATSDR or the USEPA for these chemicals, however the National Institute for Occupational Safety and Health (NIOSH) has worker recommended exposure limits (RELs) for these chemicals. The highest detected soil gas concentrations of 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene,ethyl acetate, and heptane at Hangar 6 were each far below each chemical's REL (Appendix D), which are based on a 10-hour Time Weighted Average workday.

No health-based screening value was found for 4-ethyl toluene, but the highest soil gas level detected at Hangar 6 (1,100 $\mu g/m^3$) was far below the lowest published toxic inhalation dose in animal experiments (5,000,000 $\mu g/m^3$ in rats and rabbits exposed to 4-ethyl toluene for 6 hours a day for 100 days) (NIOSH 2010).

Tentatively Identified Compounds

Appendix E presents a long list of Tentatively Identified Compounds, or "TICs". A TIC is reported when a chemical is detected in a sample extract during laboratory analysis, as evidenced by a peak on a chromatogram, but the chemical is not among the target analyte list. When this happens, software is used to compare the chemical's mass spectral pattern to the patterns for known chemicals in its library, and then propose a most probable match. The identity of each TIC is not verified by comparison with a standard of the proposed chemical, and the proposed identity may not be correct. Also, the proposed amount of the detected chemical is only a gross estimate. Another consideration with TICs is that there is limited toxicological information available to interpret the potential health significance of their presence in a sample.

Appendix E is constructed to give the reader an indication of which TICs were found most frequently, and which were tentatively identified in both soil and soil gas. In contrast to the USACHPPM report, which only acknowledged TICs identified in at least 10% of samples, Appendix E shows all reported TICs for completeness. It is not within the scope of this document to interpret the potential health significance of the large number of TICs listed in Appendix E. For many of the TICs there is little or no toxicological information available in the open literature and the potential health effects of human exposures are unknown.

Frequently Asked Questions

This section addresses some of the questions the Alaska Division of Public Health has been asked about the environmental and health records data and their meaning.

Question 1. The extensive environmental sampling data failed to identify a plausible causative agent for the worker's illnesses. Does this mean that the illnesses were caused by "mass hysteria", or was it "all in their heads"?

Answer: No. The results of the environmental sampling events do not provide a definitive answer regarding the cause of the worker's illnesses. Although the results do not pinpoint a probable causative agent, they do not prove that a chemical exposure of concern did not occur. In fact, the acute symptoms experienced by several workers support the contention that a harmful chemical exposure did in fact occur.

There are several aspects of the environmental data that may limit its effectiveness, such as:

a. Sophisticated air sampling did not occur at the same time that the acute illnesses occurred. If the workers exposed a discrete pocket of a highly volatile substance, the causative chemical could have evaporated before any sampling was performed. It was unfortunate that the field screener was not present at the time of the incident with a PID.

Air sampling on the days of the events was limited to field screening equipment, and the sampling was performed after the events occurred (not simultaneously). That later-in-the-same-day air sampling was performed using field screening devices. Hand-held field screening devices have higher detection limits than more sophisticated laboratory testing methods have, and are less capable of definitively identifying specific chemicals.

Following the first incident on June 29th, 2006, air sampling was conducted for Volatile Organic Compounds (VOCs) using a non-specific PID. Following the second incident that occurred on June 30th, 2006 the Fort Wainwright Fire Department responded with an emergency field-screening device called the HazMat ID Command System®. That system is able to identify several types of chemicals, including some chemical warfare agents, industrial chemicals and pesticides. During the June 30th, 2006 screening, the HazMat system detected two chemicals but was unable to identify either with sufficient confidence to be considered reliable (tentative identification was formaldehyde and the metal tellurium). These two compounds were not identified in later sampling.

b. The major sampling events may not have been representative of the exposure events. That is, investigators may not have been sampling for the right chemical, in the right matrix (soil, water, soil gas or air), at the right time. While many chemicals were tested for, the possible number of chemicals in the environment is extremely large. Given the chemical changes that could have occurred over time through microbial degradation, environmental weathering or burning, it is not possible to comprehensively test for every potential chemical that could exist in the environment. Similarly, at the time of exposure, weather conditions or watering for dust suppression may have resulted in a chemical reaction that created a volatile compound. As stated previously, if the workers broke into a discrete pocket of a highly volatile substance, the causative chemical could have evaporated before any sampling was performed.

It is unfortunate that the attending physicians did not obtain blood and urine specimens from the workers when they initially reported to the hospital following the exposures. As with environmental sampling, many highly volatile compounds have very short biological half-lives and must be tested promptly. While the physicians would not have known what specific analytes to test for in the clinical specimens, the public health laboratory network may have been able to assist had they been engaged immediately. The network has methods to identify unknown toxicants in clinical specimens of public health importance.

Question 2. Are there chemicals of potential concern that weren't tested for?

Answer: As explained above, it is not possible to test environmental samples for a complete list of every possible chemical in existence.

Many chemical warfare agents were not tested for. Tests from the Edgewood Chemical and Biological Center (DOD laboratory) only document analyses for two target chemicals – the breakdown products of sulfur mustard agent HD (1,4-thioxane and 1,4-dithiane) and lewisite. No results were provided to indicate that other chemical warfare agents, such as nerve agents, choking agents, nitrogen mustard agents, or tearing agents, were tested for. Therefore, their absence cannot be inferred. This is particularly unfortunate since several workers are concerned about potential long-term nervous system damage.

Phosphine and phosphides were not analyzed for in the sampling events for Hangar 6. Metal phosphides are common fumigants and rotenticides. They react rapidly with water or moisture resulting in the release phosphine gas. Impurities in phosphine give it a decaying fish or garlic odor. Non-lethal case reports from a group of workers exposed to phosphine gas included symptoms of headache, diarrhea, nausea, vomiting, abdominal pain, chest tightness, dyspnea, and dizziness. Symptoms in other case reports included numbness, lethargy, dry mouth, vertigo, weakness, and myalgia (NRC 2007). Several metals were reported in the soil that are commonly found in soils and are also used in metal phosphides. Event causation cannot be determined made for this group of compounds because: the metals detected in the soil were similar to or below the reported chemical composition for soils in Fairbanks (e.g. similar to background); Alaska (USGS 1984), it is unknown whether or not metal phosphides were present in Hangar 6; and there is no analysis (e.g. we do not have data) of phospides or phosphine available to evaluate.

The commonly used solvent trichloroethylene was measured in soil gas at 5.7 µg/m^3 and was not detected in soil samples. Because of the fire in 2004, it is possible that trichloroethylene may have been incinerated. One by-product of incomplete incineration is dichloroacetylene; dichloroacteylene was not analyzed in any sample. Dichloroacetylene is a volatile, reactive liquid with a disagreeable, sweetish odor. Acute high exposure to dichloroacetylene causes headache, nausea, vomiting, eye redness, sore gums, painful jaws, loss of sensation in the lips, facial herpes, loss of appetite, and fatigue. Dichloroacetylene is a neurotoxin that particularly targets the trigeminal nerve and other cranial nerves. Although this chemical was not analyzed for in the samples, the pattern of neurotoxicity observed in the workers is not consistent with dichloroacetylene exposure.

Question 3: What is TOCP, and why was its detection in soil samples of interest?

Answer: TOCP is the acronym for tri-ortho cresyl phosphate. It is an organophosphate compound that is toxic to the nervous system. TOCP can cause a sensorimotor central peripheral distal axonopathy called organophosphate-induced delayed neurotoxicity (OPIDN), without inducing acute cholinergic poisoning. TOCP was identified in soil at very low levels in the July and September sampling events. It is plausible that TOCP may be at the site because it is an ingredient of some aircraft lubricants.

The identification of TOCP in soil samples was of particular interest because several workers complained of delayed neurological symptoms, including tingling of the hands, a burning sensation in the feet, and loss of balance due to vestibular nerve damage. Workers also described gastrointestinal symptoms similar to those reported in historical ingestion exposures. However, it is unlikely that TOCP is the causative agent for these symptoms. Firstly, TOCP was only detected at very low levels "below the quantitation limit, but greater than zero". Secondly, the specific type of nervous system damage reported by several workers is fundamentally different than the type of damage caused by TOCP. The clinical picture of an acute TOCP-induced OPIDN is a progressive neuropathy that begins days to weeks after exposure and culminates in paralysis over a course of months to years. As of March 2008, no paralysis had been reported by the affected workers.

Question 4: Is there any documentation or evidence that lewisite was detected in environmental samples?

Answer: No. We attempted to determine the root source of perceptions among several workers that lewisite had been found at the site and that subsequently this information had been "covered up".

Two sources of potential confusion were identified. First, lewisite was reportedly mentioned by military personnel during a conference call in August 2006. It appears there was a misunderstanding or miscommunication about lewisite during that call, and a worker thought he heard that lewisite had been detected at the site. The person who reportedly made the statement later denied that lewisite had been found at the site, but workers stated that they did not believe her. Another potential source of confusion was a laboratory report that a worker saw, which had the word "lewisite" with a number beside it. On reviewing that laboratory report, we noted that the positive finding was merely a "positive control", or matrix spike sample, in which the laboratory added the chemical to the sample to verify that their test procedure was accurate. According to the laboratory reports provided, lewisite was not detected in any environmental samples from the site. The acute symptoms reported by workers on the days of the exposure were not consistent with lewisite exposure. The primary health effect caused by lewisite is severe blistering. Lewisite is rapidly absorbed by the eyes, skin, and lungs and is highly irritating on initial exposure. In contrast, the most common symptoms reported by the workers at the site were nausea, headache and lightheadedness. One worker did present with a few fluid-filled vesicles crusting over in the eyelid, at one week post-exposure. This was not a common finding among most of the affected workers, however.

Question 5: Does the exclusion zone present any risk to people's health, now or in the future? If not, is the site safe for any potential future land use?

Answer: The exclusion zone does not pose a current risk to human health from an inhalation hazard standpoint because it has been capped and is now covered by a parking lot. The inhalation pathway of exposure has been effectively blocked.

It is not possible to say whether all potential future uses of the land would be safe. This is because the identity of the chemical the workers were exposed to, and specific information about how it was contained within the zone's soil, was not successfully determined by the environmental investigation. Any of the following three scenarios could be the accurate one:

1) The unknown chemical was present in two distinct pockets and was very volatile. During excavation activities the pockets were opened to the atmosphere, and all of the chemical volatilized into the air. No residue remains of the chemical, and no additional

pockets of the chemical exist in the area, so the area is now completely safe for future construction activities.

2) The unknown chemical was present in the exclusion zone soil in multiple distinct pockets, and was very volatile. During excavation activities several pockets were opened to the atmosphere, and all of the chemical within them volatilized into the air. Other pockets of the chemical remain on the site, perhaps at other soil depths that were not disturbed by subsequent environmental sampling events or excavation activities. The area remains a potential hazard if excavation is performed in the future, so appropriate safety precautions should be taken by workers and following any additional excavation, the area should be capped to protect the public.

3) The unknown chemical was present sporadically within exclusion zone soils. The chemical was not a common one, and was not tested for during the environmental investigation. The chemical was not released in sufficient quantity during the environmental investigation or final construction phases to make any workers ill. There may or may not still be some of the chemical left in the zone's remaining soils.

Given the uncertainty regarding which of the above scenarios is correct, and the possibility of remaining hazard within the zone's soils, ATSDR recommends that the area remain capped. If construction activities must occur on the site at any time in the future, environmental regulators should be notified and consulted beforehand. In addition, a protective health and safety plan should be developed and implemented that takes the potential respiratory hazards to workers into account. The area should be capped at the completion of construction activities so that the soils cannot be inadvertently exposed by anyone.

Question 6: How should employers and health care providers work with public health authorities when chemical exposures like this occur?

Answer: In certain situations, State of Alaska statute requires chemical exposures to be reported to public health (ADPH 2008). Health care providers are required by law (18.15.370) to report the following two conditions to ADPH:

a. Diseases which are known or suspected to be related to environmental exposure to a toxic substance.

b. Diseases which are known or suspected to be due to a person's occupation.

Reports should be made by telephoning the Section of Epidemiology at 1-907-269-8000 during regular business hours. After hours, if a health care provider considers the situation to represent a public health emergency, the report should be made by calling 1-800-478-0084.

It can be particularly helpful to contact ADPH for immediate assistance when the identity of the chemical is unknown. ADPH has a number of resources available, including toxicologists, medical epidemiologists, public health nurses and chemists, to assist local health care providers with epidemiological investigations and decisions related to diagnosis, treatment and care. When indicated they can also engage their federal public health partners at the Centers for Disease Control and Prevention for assistance. Depending on the nature of the situation, federal resources can sometimes be obtained to conduct on-site environmental sampling and/or sophisticated chemical analyses of blood and urine specimens from exposed victims. Clinical specimens such as blood and urine may sometimes be helpful to identify which chemical a patient has been exposed to, especially in cases where future environmental sampling is compromised (for example, if the chemical was very volatile and has dissipated, or if the environment has already been cleaned following an incident). However, clinical specimens must be obtained from patients shortly after the exposure has occurred. As a general rule, specimens should be obtained within 1 day following an incident (although the timing varies by chemical) to be of any use for chemical testing.

Question 7: What do the five workers' medical records tell us about what happened? Are their symptoms consistent with exposure to a particular chemical?

Answer. Based on the immediate, acute, and short-term symptoms reported by the workers and in concurrence with the findings of the USACHPPM report, the workers did experience a chemical exposure on June 29th and June 30th, 2006 that resulted in some of their health effects. Accounts of the event and symptoms immediately and acutely experienced were consistent among the workers.

Not all symptoms were experienced by each worker. This is not unexpected given that multiple factors influence an individual's response to an exposure. These factors include environmental considerations such as the proximity to the source, length of time exposed, concentration of chemical as well as individual variations which may include age, gender, percent body fat, use of tobacco, alcohol and drugs, and pre-existing medical conditions. Medical conditions may result in increased susceptibility, interactions with medications, exacerbation of a baseline condition, altered absorption, metabolism, distribution, and excretion of the chemical. Furthermore, medical conditions can result in the reporting of a symptom attributable to the existing condition, not the chemical.

There was no single chemical identified which precisely matched the symptoms described by the workers. For human exposures, knowledge regarding health effects is often based on long-term, low concentration occupational exposures or acute, high concentration fatal accidents. Symptoms resulting from intermediate concentration exposures are not as well described in the literature and therefore, it is more difficult to attribute findings to a specific chemical when such exposures occur. The symptoms, examination findings, and medical test results from the workers, assisted in including or excluding categories of candidate compounds.

The lack of an odor description is telling since the exposure was to a fairly experienced work crew. There are some odors that are very recognizable such as solvents, petroleum hydrocarbons and sulfur-rotten egg odors. All of these were denied.

Lack or only minor complaints of any immediate mucous membrane irritation suggest that the chemical was not very water soluble. Water insoluble toxins are generally associated with less initial irritation and delayed injury. The workers had symptoms that persisted or presented within the first few days after the initial visit to the emergency room. While mustard agents have a delayed response, the minor mucosal findings, especially the minor ocular irritation point away from mustard agents. Metal taste was reported by some workers. Metal taste is typically from compounds containing metals or may result from acid reflux.

The initial symptoms described by these 5 and by the other workers near the site included headache, dizziness, nausea, and vomiting. The immediate onset of these central nervous system related symptoms suggest a rapid or direct transport to the central nervous system (of the chemical). There are numerous compounds and categories of compounds associated with such symptoms. On the other hand, the symptoms of myalgia and arthralgia are generally seen with infectious diseases and less often reported in chemical exposures.

Some physical exam findings that were not present detract from the hypothesis that the exposure was to organophosphate pesticides or nerve agents. There was no miosis, salivation or rhinorrhea reported. On follow-up visits, various neurological findings were reported, however there was little overlap of findings among workers. Solvents, metals and pesticides are all associated with neurotoxic effects.

The laboratory results were not helpful in evaluating what chemical may have been involved with the exposure. The clinical samples for xylene and its metabolites, cholinesterase, and urine arsenic and mercury were not collected within a reasonable time period of the event to provide information relevant to the exposure.

One of the imaging studies showed small airway inflammation that may be related to hypersensitivity pneumonitis or inhalational insult. Numerous chemicals are associated with small airway inflammation including solvents, metal containing compounds, and pesticides. There were some audiometric and vestibular findings from testing performed by specialists. Several solvents have been associated with ototoxicity.

Conclusions

The summary findings of this health consultation are as follows:

The overall weight of evidence indicates that a chemical exposure occurred among multiple workers at the Hangar 6 job site at Fort Wainwright, Alaska on June 29th and 30th, 2006, which was associated with documented acute health symptoms in several workers. Medical records, worker interviews and other site documents are all in agreement, and support the conclusion that multiple workers were exposed to an unknown chemical on June 29th and 30th, 2006 that harmed their short-term health. The symptoms experienced by the workers immediately and acutely are consistent with an inhalational chemical exposure. The chemical was released into the air when it was exposed during construction excavation activities. Environmental sampling conducted in the weeks to months after the exposure incident was not successful in identifying a potential causative agent. These results are not proof that a chemical exposure did not occur, because it is possible that investigators did not test for the right chemical, in the right environmental matrix, at the right time.

The long-term, chronic health effects reported by several affected workers are less consistent among individuals, than were short term acute effects. Although it is possible that a few workers may have long-term health effects from the chemical exposure incident, it is also possible that the worker's current health problems are not a direct result of the chemical exposure incident. Little is known about the baseline health status of these workers and some may have co-morbid conditions. It is also possible that some of the chronic health issues experienced by several of the workers may be a result of psychological trauma as an indirect effect of the chemical exposure.

This health consultation also validated the prior results of the USACHPPM report. That report focused solely on the potential future risks to construction workers who would finish the construction project, by assessing potential health risks of the chemicals detected in soil, air and soil gas during environmental testing. The USACHPPM report did not address the question of what chemical the workers were exposed to on June 29th and 30th, 2006, or evaluate the exposed workers health problems.

ADPH and ATSDR conclude that the USACHPPM's risk assessment was scientifically defensible, and did indicate that it was safe for workers to re-enter the exclusion site to finish construction activities. The USACHPPM report recommendations that no requirement for additional personal protective equipment to perform construction activities beyond that listed in the site health and safety plan is necessary and that a contract field screener should be on-site during future exclusion site construction activities are supported by the risk assessment.

Recommendations

1. Health care providers should contact the ADPH immediately to report either of the following two conditions as required by Alaska Statute 18.15.370:

a. Diseases which are known or suspected to be related to environmental exposure to a toxic substance;

b. Diseases which are known or suspected to be due to a person's occupation.

2. The permanent parking lot "cap" on the Hangar 6 exclusion zone site should not be disturbed at any time in the future without consulting environmental regulators. If future excavation of the site is ever planned in the future, a protective health and safety plan

should be developed and implemented that takes into account the potential exclusion zone hazards to workers. The plan should include:

a. Real-time field screening for the presence of hazardous chemicals and other unsafe conditions during excavation activities.

b. Use of a metal detector prior to conducting any excavation or trenching of soil.

3. Employers should develop protective, project-specific Health and Safety Plans for their construction workers, and adhere to the plans at all times. Employees should be provided with personal protective equipment appropriate for the job, and work should not be conducted until it is verified that the field screener is in working order.

Public Health Action Plan

Actions Undertaken:

- After first being informed of the chemical exposure incidents of 29th and 30th June 2006 on August 15th, 2006, ADPH began working with site stakeholders and contacting the health care providers who saw the exposed patients. ADPH participated in a meeting of an assembled Medical Panel of involved health care providers on September 1st, 2006.

- ADPH participated in meetings of military base officials, ADEC officials, USACHPPM and private sector construction contractors during the fall of 2006 to evaluate site environmental data, and ensure that completion of the Hangar 6 construction project did not pose undue risks to worker safety.

- Final excavation needed for construction at the Hangar 6 exclusion zone occurred on June 27th, 2007 without incident. The site has since been permanently capped with a parking lot.

- ADPH conducted outreach with military base officials, ADEC, Alaska's Statewide Hazmat Work Group and Alaska health care providers to ensure prompt notification of ADPH in the event of a future chemical exposure incident. Education was provided about the importance of prompt collection of blood and urine specimens from exposed victims, and the specific protocols to follow for the collection and shipment of clinical specimens.

Actions Planned:

- Provide this health consultation report to incident stakeholders, affected workers and other interested parties.

- ADPH will conduct ongoing, periodic outreach to Alaska military officials, emergency responders, the Statewide Hazmat Work Group, and Alaska health care providers as part of public health chemical emergency preparedness activities. This outreach will include the following components:
  - The importance of contacting ADPH immediately following a chemical exposure event that causes adverse health effects;
  - Specific protocols for the collection and shipment of clinical specimens following a chemical exposure event.

Authors of the Report

Lori Verbrugge, PhD
State of Alaska Department of Health and Social Services
Division of Public Health, Section of Epidemiology
Anchorage, AK

Michelle Watters, MD, PhD, MPH
Medical Officer, Division of Regional Operations
Agency for Toxic Substances and Disease Registry
Chicago, IL

Reviewers of the Report

Audra Henry
Technical Project Officer
Division of Health Assessment and Consultation
Agency for Toxic Substances and Disease Registry
Atlanta, GA

Tina Forrester, PhD
Division Director
Division of Regional Operations
Agency for Toxic Substances and Disease Registry
Atlanta, GA

References

ADEC (Alaska Department of Environmental Conservation), July 1990. RCRA Facility Assessment: Preliminary Review and Visual Site Inspection. U.S. Army, Fort Wainwright, Fairbanks Alaska, EPA ID #AK6210022426.

ADPH (Alaska Division of Public Health). January 2008. Conditions reportable to public health. Section of Epidemiology, Department of Health and Social Services, State of Alaska. Available at
http://www.epi.hss.state.ak.us/pubs/conditions/ConditionsReportable.pdf

References

ATSDR (Agency for Toxic Substances and Disease Registry). 1999a. Health Consultation: Use of Groundwater for Lawn Irrigation, Fort Wainwright/Shannon Park Baptist Church. Atlanta: U.S. Department of Health and Human Services.

ATSDR. 1999b. Letter of Technical Assistance to Ms. Deardorff Concerning Learning Disabilities and Attention Deficit Disorders at Local Schools. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2000. Toxicological Profile for Toluene. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2003. Public Health Assessment for Fort Wainwright, Fairbanks North Star Borough, Alaska, September 30, 2003.

ATSDR 2005. Public Health Assessment Guidance Manual. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2006. Toxicological Profile for Dichlorobenzenes. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2007a. Toxicological Profile for Benzene. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2007b. Toxicological Profile for Xylene. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2010a. Draft Toxicological Profile for 1,3-Butadiene. Atlanta: U.S. Department of Health and Human Services.

ATSDR 2010b. Carbon Disulfide: Medical Management Guidelines. Atlanta: U.S. Department of Health and Human Services.

NIOSH (National Institute for Occupational Safety and Health). 2010. Registry of Toxic Effects of Chemical Substances Database. Available at www.cdc.gov/niosh/rtecs/default.html. Last updated 2010.

NRC (National Research Council). 2007. Acute Exposure Guidelines for Selected Airborne Chemicals Volume 6. Chapter 10, Phosphine and Eight Metal Phosphides. National Academies Press, Washington, D.C

North Wind, Inc. September 2007. Technical Memorandum – Site Investigation and Removal Action at FWA-021, Former Hangar 6, Fort Wainwright, Alaska. Contract No. W9128F-04-D-0017.

USACHPPM (U.S. Army Center for Health Promotion and Preventive Medicine) 2007. Occupational and Environmental Risk Assessment of the Hangar 6, Exclusion Site. USACHPPM Survey No. 55-ML-0P3-07, Fort Wainwright, Alaska June 2006-April 2007. Aberdeen Proving Grounds, MD.

USEPA (United States Environmental Protection Agency). March 2003. Toxicological Review of Methyl Isobutyl Ketone (CAS 108-10-1). Washington, D.C. http://www.epa.gov/iris/toxreviews/0173tr.pdf

USGS (United States Geological Survey). 1984. Chemical Analyses of Soils and Other Surficial Materials, Alaska. Open–File Report 84-423. United States Department of the Interior.

Appendices

- A - List of environmental data reports reviewed
- B - Chemicals tested for but not detected in any sample
- C - Detects in soil with comparison to screening values
- D - Volatile organics in soil, soil gas, and water
- E - Tentatively identified compounds
- F - Description of screening criteria
- G - USACHPPM report - verification of representative risk assessment calculations and reprint of the report's conclusions

Appendix A. Environmental Sampling Events - Data Reviewed			
Sampling Date	**Media**	**# samples**	**Description**
June 30-July 1, 2006	Soil	3	Fuel, metals, organochlorine pesticides, PCBs, VOCs, semivolatiles, cyanide, chlorinated herbicides
July 9-10-, 2006	Soil	9	Isocyanate, 1,4-dithiane, 1,4-thioxane, [illegible]
July 9, 2006	Soil	8	VOCs, semivolatiles
July 9, 2006	Water	1	VOCs
August 11, 2006	Soil	7	Metals, glycols,
August 11, 2006	Air (ambient)	6	VOCs
August 11, 2006	Air (ambient)	2	Metals, pesticides, VOCs, arsine, organosulfur compounds, organonitrogen pesticides
August 11, 2006	Subsurface soil	7	Semivolatiles, fuel, organophosphorus and organochlorine pesticides, metals, mercury, organochlorine herbicides, phenol, cyanide
August 11, 2006	Water	2	VOCs, GRO
September 22-23, 2006	Soil vapor	14	VOCs
September 22-27, 2006	Soil	30	25 of these samples were taken from the top 6 inches of soil, after clean fill was added and the area re-graded, to confirm that the area was now clean. Three of the samples (06HG30S01, 06HG27SO1 and 06HG28S01) were collected from the bottoms of the deeper excavations. Semivolatiles, PCBs, metals, mercury, organochlorine and organophosphorous pesticides, chlorinated herbicides, VOCs
September 25, 2006		5	VOCs
September 26, 2006	Soil	2	o-tricresylphosphate
October 3, 2006	Stockpile soil	17	Semivolatiles, fuel, PCBs, metals, mercury, organochlorine and organophosphorus pesticides, chlorinated herbicides, VOCs
October 3, 2006	Stockpile soil	3	o-tricresylphosphate

Appendix B. Chemicals Tested for and Not Detected in Any Sample (Above Blank)		
CHLORINATED HERBICIDES BY GC-MS	Looked for in Soil	
	Common Detection Limit (ppb)1	
2,4-D	0.8	
Pentachlorophenol	1.9	
Silvex (2,4,5-TP)	2.1	
2,4,5-T	0.57	
Dinoseb	2.3	
2,4-DB	1.6	
GLYCOLS	Looked for in August soil samples only	
	Detection Limit (ppm)	
Propylene glycol	25	
Ethylene glycol	25	
ANIONS	Looked for in August soil samples only	
	Common Detection Limit (ppm)2	
Chloride	0.06	
Bromide	0.15	
Nitrate	0.03	
Orthophosphate	0.35	
PCBs 8082	Looked for in Soil	
	Common Detection Limit (ppm)2	
Aroclor 1016	0.034	
Aroclor 1221	0.034	
Aroclor 1232	0.034	
Aroclor 1242	0.034	
Aroclor 1248	0.034	
Aroclor 1254	0.034	
Aroclor 1260		Only looked for in August soil samples
Aroclor 1268		Only looked for in August soil samples
CYANIDES total	Only looked for in 3 early samples (J/J)	
	Common Detection Limit (ppm)2	
	0.52	
CHEMICAL AGENTS & BREAKDOWN PRODUCTS	Only looked for in early J/J samples	
	Detection Limit (ppm)	
1,4-Dithiane	0.1	
1,4-Thioxane	0.1	
HD (Distilled mustard)	0.1	
L (Lewsite)	0.1	

Appendix B. Chemicals Tested for and Not Detected in Any Sample (Above Blank)				
ISOCYANATES	Only looked for in early J/J samples			
	Detection Limit (ppm)			
4,4-Methylenediphenylisocyanate (M	7			
Toluene-2,4-Diisocyanate(2,4-TDI)	7			
Toluene-2,6-Diisocyanate (2,6-TDI)	7			
	Common Method Detection Limit (ppb), per matrix2			
VOLATILE ORGANICS	Soil	Soil Gas	Water (ug/L)	
Bromobenzene	6.1	n/a	0.18	
Bromochloromethane	4.8	n/a	0.31	
Bromodichloromethane	3.3	0.08	0.14	
Bromomethane	14	0.215	0.08	
tert-Butylbenzene	2.7	n/a	[illegible]	
Carbon tetrachloride	3.8	0.066	[illegible]	
Chloroethane	9.8	0.388	[illegible]	
2-Chlorotoluene	2.5	n/a	0.26	
4-Chlorotoluene	2	n/a	0.10	
Dibromochloromethane	4.4	[illegible]	0.40	
1,2-Dibromo-3-chloropropane	35	n/a	[illegible]	
1,2-Dibromoethane	3.8	0.119	[illegible]	
Dibromomethane	4.5	n/a	[illegible]	
1,1-Dichloroethane	3.9	0.116	0.10	
1,2-Dichloroethane	3.3	[illegible]	0.22	
1,1-Dichloroethene	6.0	0.109	0.36	
cis-1,2-Dichoroethene	5.7	[illegible]	[illegible]	
1,2-Dichloropropane	3.3	0.123	[illegible]	
1,3-Dichloropropane	3.1	n/a	0.20	
2,2-Dichloropropane	3.0	n/a	0.13	
1,1-Dichloropropene	3.0	n/a	0.14	
cis-1,3-Dichloropropene	[illegible]	0.106	0.22	
trans-1,3-Dichloropropene	3.1	0.13	0.30	
Hexachlorobutadiene	7.7	0.119	0.22	
Methyl tert-butyl ether	[illegible]	0.147	1.00	
2-Hexanone	[illegible]	0.136	1.00	
1,2,3-Trichlorobenzene	4.3	n/a	0.14	
1,1,1,2-Tetrachloroethane	4.1	n/a	0.10	
1,1,2,2-Tetrachloroethane	4.0	0.108	0.37	
Trichlorofluoromethane	3.4	n/a	0.23	
1,2,3-Trichloropropane	35	n/a	0.30	
Vinyl chloride	4.9	0.301	0.12	
Freon 114	n/a	0.156	n/a	
Benzyl chloride	n/a	0.136	n/a	

Appendix B. Chemicals Tested for and Not Detected in Any Sample (Above Blank)				
	Looked for in soil only			
SEMIVOLATILE ORGANICS	Common Method Detection Limit (ppb)1			
Aniline	350		aniline only tested in 3 samples	
Azobenzene	28			
Benzyl alcohol	180			
Bis(2-chloroisopropyl)ether	33			
4-Bromophenyl phenyl ether	24			
Butyl benzyl phthalate	20			
Carbazole	57			
4-Chloroaniline	60			
4-Chloro-3-methylphenol	15			
	looked for in soils only			
	Common Method Detection Limit (ppb)1			
2-Chlorophenol	23			
4-Chlorophenyl phenyl ether	15			
Dibenz (a,h) anthracene	18			
1,3-Dichlorobenzene	41			
2,4-Dichlorophenol	22			
Dimethyl phthalate	24			
4,6-Dinitro-2-methylphenol	690			
2,4-Dinitrophenol	690			
2,4-Dinitrotoluene	22			
2,6-Dinitrotoluene	31			
Hexachlorobenzene	18			
Hexachlorocyclopentadiene	50			
Hexachlorobutadiene	34			
Hexachoroethane	48			
Isophorone	18			
2-Methylphenol	60			
3- and 4-methylphenol	340			
2-Nitroaniline	[illegible]			
3-Nitroaniline	170			
4-Nitroaniline	39			
Nitrobenzene	[illegible]			
2-Nitrophenol	[illegible]			
4-Nitrophenol	690			
N-nitrosodimethylamine	40			
N-Nitrosodiphenylamine	25			
N-Nitrosodi-n-propylamine	19			
Pentachlorophenol	690			
Phenol	20			
1,2,4-Trichlorobenzene	28			
2,4,5-Trichlorophenol	38			
2,4,6-Trichlorophenol	55			
m,p-cresols	350			
o-cresol	350			
1=Detection Limit varied by Sample and by Sampling Event				
2=Detection Limit varied slightly by Sample				
n/a = not analyzed				

Appendix C. Chemicals Detected in Soil (Except Volatile Organics, which are presented separately in Appendix D)					
Chemical				Sample with highest conc	Sample Description
	Description of Comparison Value1	Comparison Value (ppm)	Highest Soil Conc (ppm)		
FUELS:					
GRO	ADEC Method 2 - Inhalation pathway	1400	767	06AMHSL03	Site 15 soil
DRO	ADEC Method 2 - Inhalation pathway	12500	2800	06HG57SO1	Stockpile soil
RRO	ADEC Method 2 - Inhalation pathway	22000	[illegible]	06HG66SO1	Stockpile soil
METALS	**Description of Comparison Value**	**Comparison Value (ppm)**	**Highest Soil Conc (ppm)**		
Phosphorus	**Column1**	**Column2**	**501**	**06HG39S01**	**Soil Sept**
Strontium	ATSDR Int. EMEG (adult)	1,000,000	27.6	06HG39S01	Soil Sept
Aluminum	ATSDR Chronic EMEG (adult)	700,000	9060	06HG39S01	Soil Sept
Antimony	ATSDR RMEG (adult)	300	0.78	06HG48SO1	Soil Sept
Arsenic	ATSDR Chronic EMEG (adult)	200	6.7	06HG39S01	Soil Sept
Barium	ATSDR Chronic EMEG (adult)	100,000	193	06HG42SO1	Soil Sept
Beryllium	ATSDR Chronic EMEG (adult)	1,000	0.15	06HG39S01	Soil Sept
Cadmium	ATSDR Chronic EMEG (adult)	70	0.61	06HG36S01	Soil Sept
Calcium			5790	06HG39S01	Soil Sept
Chromium	ATSDR Chronic EMEG for hexavalent	700	26.4	06HG48SO1	Soil Sept
Cobalt	ATSDR Int. EMEG (adult)	7,000	6.8	06HG48&39SO	Soil Sept
Copper	ATSDR Int. EMEG (adult)	7,000	19	06HG60S01	Stockpile soil
Iron			15400	06HG39S01	Soil Sept
Lead	EPA screening level for residential	400	134	06HG48SO1	Soil Sept
Magnesium			5190	06HG39S01	Soil Sept
Manganese	ATSDR RMEG (adult)	40,000	271	06HG39S01	Soil Sept
Molybdenum	ATSDR RMEG (adult)	4,000	0.61	06HG48SO1	Soil Sept
Nickel			18.3	06HG39S01	Soil Sept
Potassium			853	06HG39S01	Soil Sept
Selenium	ATSDR Chronic EMEG (adult)	4,000	0.43	06HG69S01	Soil Sept
Silver	ATSDR RMEG (adult)	4,000	0.22	06HG36S01	Soil Sept
Sodium			368	06HG50S01	Soil Sept
Vanadium	ATSDR RMEG (adult)	2,000	31.1	06HG39S01	Soil Sept
Zinc	ATSDR Chronic EMEG (adult)	200,000	112	06HG48SO1	Soil Sept
Mercury	ATSDR Chronic EMEG for MethylHg	200	0.046	06HG27SO1	Soil Sept

Appendix C. Chemicals Detected in Soil (Except Volatile Organics, which are presented separately in Appendix D)					
CHLORINATED PESTICIDES	**Description of Comparison Value**	**Comparison Value (ppb)**	**Highest Soil Conc (ppb)**		
alpha-BHC	ATSDR Chronic EMEG (adult)	6,000,000	0.12 J	06HG57SO1	Stockpile Soil
beta-BHC	ATSDR Int. EMEG (adult)	400,000	0.5	06HG58SO2	Stockpile Soil
delta-BHC			0.58	06HG57SO1	Stockpile Soil
4,4'-DDD			22	06HG48SO1	Soil Sept
4,4'-DDE			10 J	06HG47SO1	Soil Sept
4,4'-DDT	ATSDR Int. EMEG (adult)	400,000	35	06HG71SO1	Stockpile Soil
Dieldrin	ATSDR Chronic EMEG (adult)	40,000	2	06HG10SO1	Soil Aug
Endosulfan I	ATSDR Chronic EMEG for endosulfan	1,000,000	0.61	06HG67SO1	Stockpile Soil
Endosulfan II	ATSDR Chronic EMEG for endosulfan	[illegible]000,000	[illegible]0 J	06HG59SO1	Stockpile Soil
Endosulfan sulfate	ATSDR Chronic EMEG for endosulfan	1,000,000	2.6	06HG10SO1	Soil Aug
Endrin	ATSDR Chronic EMEG (adult)	2[illegible]	4.8	06HG70SO1	Stockpile Soil
Endrin aldehyde			0.71	06HG59SO1	Stockpile Soil
Heptachlor	ATSDR Int. EMEG (adult)	70,000	0.27 J	06HG57SO1	Stockpile Soil
Heptachlor epoxide	ATSDR RMEG (adult)	9,000	1.1 J	06HG48SO1	Soil Sept
Methoxychlor	ATSDR Int. EMEG (adult)	4,000,000	8.0 J	06HG10SO1	Soil Aug
Endrin ketone			0.84	06HG70SO1	Stockpile Soil
alpha-Chlordane	ATSDR Chronic EMEG for chlordane	[illegible]	0.26 J	06HG68SO1	Stockpile Soil
gamma-Chlordane	ATSDR Chronic EMEG for chlordane	400,000	0.44 J	06HG10SO1	Soil Aug
ANIONS	Only looked for [illegible] soil samples				
Column1	**Column2**	**Column3**	**Column4**	**Column5**	**Column6**
Fluoride			0.11 J mg/kg	06HG12SO1	Soil Aug
Sulfate			6.5 mg/kg	06HG13SO1	Soil Aug
Nitrite			0.16 J mg/kg	06HG11SO2	Soil Aug
PCBs 8082	**Description of Comparison Value**	**Comparison Value (ppb)**	**Highest Soil Conc (ppb)**		
Aroclor 1260	[illegible] EMEG [illegible] aroclor 1254	10,000	30 J	06HG48SO1	Soil Sept
o-tricresylphosphate	Only looked [illegible] 5 samp[illegible] from Sept		0.052 J mg/kg	06HG29SO1	Soil Sept

Appendix C. Chemicals Detected in Soil (Except Volatile Organics, which are presented separately in Appendix D)				
SEMIVOLATILE ORGANICS	Description of Comparison Value	Comparison Value (ppb)	Highest Soil Conc (ppb)	Sample ID
Acenaphthene	ATSDR Chronic EMEG (adult)	400,000,000	230 J	06HG36SO1
Acenaphthylene			99 J	06HG27SO1
Anthracene	ATSDR Int. EMEG (adult)	1,000,000,000	350 J	06HG36SO1
Benzo (a) anthracene			1600 J	06HG36SO1
Benzo(b)-fluoranthene			1400 J	06HG47SO1
Benzo (k) fluoranthene			1900 J	06HG36SO1
Benzoic acid	ATSDR RMEG (Adult)	1,000,000,000	1710	06AMHSL03
Benzo (ghi) perylene			610 J	06HG47SO1
Benzo(a)pyrene			1600 J	06HG36SO1
Bis(2-ethylhexyl) phthalate	ATSDR Chronic EMEG (adult)	4[illegible],000	510	06HG08SO1
2-Chloronaphthalene	ATSDR RMEG (Adult)	60,000,000	44 J	06HG27SO1
Chrysene			1800 J	06HG36SO1
Di-n-butyl phthalate			300 J	06HG29SO1
Dibenzofuran			120 J	06HG27SO1
1,2-Dichlorobenzene	EPA RSL, Industrial Soil, Inhalation HI	12,000	16	06HG57SO1
1,4-Dichlorobenzene	EPA RSL, Industrial Soil, Inhalation HI	42,000	770 J	06HG57SO1
3,3-Dichlorobenzidine			44 J	06HG13SO1
Diethyl phthalate	ATSDR Int. EMEG (adult)	[illegible]0,000,000	120 J	06HG43SO1
2,4-Dimethylphenol	ATSDR RMEG (Adult)	10,000,000	570	06HG09SO1
Di-n-octyl phthalate			48 J	06HG13SO1
Fluoranthene	ATSDR Int. EMEG (adult)	300,000,000	2900 J	06HG36SO1
Fluorene	ATSDR Int. EMEG (adult)	300,000,000	150 J	06HG09SO1
Indeno (1,2,3-cd) pyrene			850 J	06HG47SO1
1-Methylnaphthalene	ATSDR Chronic EMEG (adult)	50,000,000	2790	06AMHSL05
2-Methylnaphthalene	ATSDR Chronic EMEG (adult)	30,000,000	4150	06AMHSL05
Naphthalene	ATSDR Int. EMEG (adult)	400,000,000	10000	06HG09SO1
Phenanthrene			1500 J	06HG36SO1
Pyrene	ATSDR RMEG (Adult)	20,000,000	3900	06HG36SO1
J= Estimated result. Result is less than Reporting Limit				

1=ATSDR soil comparison values are of limited utility as they evaluate a soil INGESTION pathway. EPA screening levels evaluating the INHALATION pathway from soil were used when available. Refer to Appendix F for a description of screening criteria.

Appendix D. Volatile Organics in Soil, Soil Gas and Water

	SOIL					SOIL GAS			
VOLATILE ORGANICS	Desc. of Comparison Value1	Comparison Value (ppb)	Highest Soil Conc (ppb)	Sample ID	Sample Desc.	Desc. of Comparison Value1	Comparison Value (ug/m3)	Highest Soil Gas (ug/m3)	Sample ID
Acetone	ATSDR Int. EMEG (adult)	1,000,000,000	2,500	06HG38SO1	Soil Sept	ATSDR Chronic EMEG	30,000	420	06HG28GS
Benzene			n/d			ATSDR EMEG (Chronic/Acute)	10/30	180	06HG28GS
Bromoform	ATSDR Chronic EMEG (adult)	10,000,000	53 J	06HG58SO1	Stockpile soil				
2-Butanone	ATSDR RMEG (adult)	400,000,000	56 J	06TB71	Stockpile soil	EPA RfC	5,000	180	06HG28GS
n-Butylbenzene			9,900	06HG09SO1	June & July				
sec-Butylbenzene			4,200	06HG09SO1	June & July				
Carbon disulfide			n/d above blank			ATSDR Chronic EMEG	900	45	06HG24GS
Chlorobenzene			n/d					1.2 J	06HG20GS
Chloroform			n/d			ATSDR Chronic EMEG	100	8.3	06H601AS
Chloromethane			n/d			ATSDR Chronic EMEG	100	1.2	06H604AS
1,2-Dichlorobenzene	ATSDR Chronic EMEG (adult)	200,000,000	63,000 E	06HG5[illegible]	Stockpile soil			1100	06HG22GS
1,3-Dichlorobenzene			n/d					48	06HG29GS
1,4-Dichlorobenzene	ATSDR Chronic EMEG (adult)	50,000,000	2,800	06HG57SO1	Stockpile soil	**ATSDR EMEG (Chronic/Acute)**	**60/10,000**	**180 E**	**06HG22GS**
Dichlorodifluoromethane			n/d					50	06HG32GS
trans-1,2-Dichloroethene			n/d			ATSDR Intermediate EMEG	800	3.6	06HG28GS
Ethylbenzene	ATSDR Int. EMEG (adult)	400,000,000	2,800	06HG11SO1	Aug soil	ATSDR Chronic EMEG	1,000	550	06HG29GS
n-Hexane			n/d			ATSDR Chronic EMEG	2,000	78	06HG28GS
Isopropylbenzene			3,400	06HG14SO1	Aug soil				
p-Isopropyltoluene			11,000	06HG09SO1	June & July				
4-Methyl-2-pentanone			130 J	06HG58SO1	Stockpile soil	EPA RfC	3,000	3200 E	06HG33GS
Methylene chloride			n/d above blank					18	06HG28GS
Naphthalene			23,000	06HG09SO1	June & July soil				
n-Propylbenzene			8,400	06HG11SO1	[illegible]				
Styrene			n/d			ATSDR Chronic EMEG	900	32	06HG29GS
1,2,4-Trichlorobenzene	ATSDR RMEG (adult)	7,000,000	150 J	06HG57SO1	Stockpile soil				
Tetrachloroethene			n/d					23	06HG20GS
Toluene	ATSDR Int. EMEG (adult)	10,000,000	[illegible]	06HG11SO1	Aug soil	**ATSDR EMEG (Chronic/Acute)**	**300/4,000**	**1500 E**	**06HG33GS**
1,1,1-Trichloroethane	ATSDR Int. EMEG (adult)	1,000,000,000	310	06HG58SO1	Stockpile soil				
1,1,2-Trichloroethane	ATSDR Int. EMEG (adult)	30,000,000	[illegible] J	06HG59SO1	Stockpile soil				
Trichloroethene			n/d			ATSDR Chronic EMEG	300	5.7	06HG32GS
1,2,4-Trimethylbenzene			[illegible]	06HG09SO1	June & July soil	NIOSH REL, 10-hr TWA	125,000	1600 E	06HG29GS
1,3,5-Trimethylbenzene			55,000	06HG09SO1	June & July soil	NIOSH REL, 10-hr TWA	125,000	1300 E	06HG29GS
o-xylene			[illegible]7,500	[illegible]MHSL03	June & July soil			9200 E	06HG28GS
m,p-xylene			63,000	06HG11SO1	Aug soil			16000 E	06HG29GS
total Xylenes	ATSDR Chronic EMEG (adult)	100,000,000	[illegible]	06HG09SO1	June & July soil	**ATSDR EMEG (Chronic/Acute)**	**200/9,000**		
Propene								1700 E	06HG28GS
1,3-Butadiene						**EPA RfC**	**2**	**290**	**06HG28GS**
Freon 12								2.2 J	06HG32GS
Freon 113								1.0 J	06H604GB
Vinyl acetate						ATSDR Intermediate EMEG	40	26	06HG20GS
Ethyl acetate						NIOSH REL, 10-hr TWA	1,400,000	3500 E	06HG20GS
Tetrahydrofuran								9.4	06HG26GS
Cyclohexane						EPA RfC	6,000	610	06HG29GS
Heptane						NIOSH REL, 10-hr TWA	350,000	1700	06HG29GS
4-Ethyl toluene						NIOSH RTEC database	5,000,000	1100	06HG29GS

1= Soil comparison values are selected solely as they evaluate the INGESTION pathway. The more relevant exposure pathway for this site was the INHALATION pathway from soil. Refer to Appendix F for a description of the screening criteria

J = Estimated result. Result is less than Reporting Limit

E = Reported value exceeds analytical calibration range

Analytes in BOLD exceed at least one screening value

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v	Sample w/ highest soil gas	# samples detected (out of 30 samples)	Notes
(all in ppb v/v est.)							
Ethanol				77	06H604GB	15	
Isopropyl alcohol				64	06HG20GS	2	
2-pentanone				11	06HG20GS	1	
Hexane, 3-methyl				[illegible]	06HG29GS	2	
Acetic acid, butyl ester				2.2	06HG20GS	1	
Heptane, 2,4-dimethyl				2.3	06HG20GS	1	
Cyclohexane, C5 subst				4.7	06HG21GS	2	
Cyclohexane, C4 subst				7.2	06HG21GS	2	
Decane	8900	06HG29SO1	5	23	06HG32GS	3	
Decane, 4-methyl-	15000	06HG29SO1	15	66	06HG25GS	7	
Cyclohexane, (1-methylpropyl)-				3.6	06HG20GS	1	
C11 Hydrocarbon				2.9	06HG20GS	1	
Undecane	14000	06HG11SO1	41	67	06H602GB	2	
Ethane, 1-chloro-1,1-difluoro-				1700	06HG32GS	7	
Isobutene*				6.1	06HG21GS	2	
1,2-butadiene				3.5	06HG21GS	1	
C5 Alkene				4	06HG21GS	1	
1,3-cyclopentadiene				290	06HG28GS	2	
C11 Alkene				14.3	06HG21GS	1	
C11 cyclic hydrocarbons				2030	06HG29GS	12	
C12 cyclic hydrocarbons				460	06HG29GS	10	
Cyclohexane, 1,1-dimethyl-2-propyl-				36	06HG23GS	5	
Naphthalene, decahydro-	58000	06HG57SO1	6	580	06HG29GS	12	
Adamantane	[illegible]	06H[illegible]7SO1	1	350	06HG29GS	7	
Naphthalene, decahydro-2-methyl-	42000	06HG58SO1	9	32	06H601GB	8	
Cyclohexane, 1,2-dimethyl-	4200	[illegible]6HG57[illegible]	2	380	06HG29GS	4	
Cyclohexane, 1,1,3-trimethyl-	15000	06HG29SO1	4	46	06HG22GS	9	
Cyclohexane, 1,2,4-trimethyl-				42	06HG22GS	6	
C10 cyclic hydrocarbons				120	06HG23GS	8	
Cyclopentane, (1-methylbutyl)*				26	06HG22GS	1	
Heptane, 4-(1-methylethyl)-*				25	06HG22GS	1	
Cyclohexane, 1,1,2,3-tetrameth*				42	06HG22GS	3	
C10 Alkene				74	06HG22GS	1	
Cyclohexane, methyl*	1570	06AMHSL03	2	840	06HG29GS	5	
Hexane, 2,4-dimethyl-				470	06HG29GS	2	
Hexane, 2,5-dimethyl-	700	06HG64SO2	1	15	06HG24GS	1	

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v est)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Heptane, 3-methyl-	7100	06HG11SO1	4	860	06HG29GS	4	
Cyclohexane, 1,3-dimethyl-				840	06HG29GS	4	
Cyclohexane, ethyl-				650	06HG29GS	4	
Cyclohexane, 1-ethyl-2-methyl-				27	06HG26GS	2	
Benzene, 1-ethyl-3-methyl-	70000	06HG11SO1	13	[illegible]	06HG24GS	1	
Benzene, 1-methyl-2-(1-methyle	17300	06HG58SO2	13	19	06HG25GS	3	
Benzene, 4-ethyl-1,2-dimethyl-	55000	06HG09SO1	8	430	06HG29GS	8	
Benzene, 1-ethyl-2-methyl-	61000	06HG09SO1	6	76	06H604GB	4	
Trans-Decalin, 2-methyl-	26000	06HG29SO1	[illegible]	16	06HG25GS	3	
Nonane	390	06HG11SO2	1	360	06HG29GS	4	
Bicyclo (3.3.1) nonane				17	06HG27GS	1	
Octane, 2,6-dimethyl-	54	06HG50SO1	1	28	06HG27GS	2	
Pulegone				32	06H602GB	3	
Cyclopropane, 1,2-dimethyl-				200	06HG28GS	1	
1,3-butadiene, 2-methyl-				220	06HG28GS	1	
1-hexene				170	06HG28GS	1	
2-Pentene, 3-methyl-				520	06HG28GS	1	
Pentane, 2,4-dimethyl-				170	06HG28GS	1	
Pentane, 2,3-dimethyl-				340	06HG28GS	1	
C7 Alkene				720	06HG28GS	1	
C8 Hydrocarbons				18500	06HG28GS	1	
C8 Alkene				210	06HG28GS	1	
Cyclopentane, 1,1,3-trimethyl-				7900	06HG28GS	1	
Cyclopentane, 1,2,4-trimethyl-				1800	06HG28GS	1	
Cyclopentane, 1,2,3-trimethyl-				3200	06HG28GS	1	
C9 Cyclic Hydrocarbon				3000	06HG28GS	1	
Cyclooctane, methyl-	420	06HG10SO1	1	2400	06HG28GS	1	
Cyclohexane, 1,2,3-trimethyl-				2100	06HG28GS	1	
Cyclohexane, 1-ethyl-4-methyl-				1700	06HG28GS	1	
Pentane, 2,3,4-trimethyl-	1430	06AMHSL03	1	470	06HG29GS	2	
Heptane, 2-methyl-	1940	06AMHSL03	2	880	06HG29GS	3	
Octane	7000	06HG11SO1	2	470	06HG29GS	3	
Octane, 3-methyl-	1350	06AMHSL03	2	430	06HG29GS	3	
Butane, 2,2,3,3-tetramethyl-				39	06HG30GS	1	

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v [illegible]est)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Nonane, 2,6-dimethyl-				42	06HG30GS	2	
Benzene, 1-ethyl-3,5-dimethyl-	7110	06AMHSL03	1	20	06HG31GS	2	
2-propanol, 2-methyl-				3.4	06HG33GS	1	
2-Butenoic acid, methyl ester				3.4	06HG33GS	1	
Adamantane, 1,3-dimethyl-	1800	06HG08SO1	1	11	06H601GB	1	
Cyclododecene				6[illegible]	06H601GB	1	
Cyclohexane, 1-methyl-2-propyl-	3200	06HG57SO1	1	12	06H602GB	1	
Undecane, 5-methyl	18000	06HG29SO1	1	18	06H602GB	1	
Dodecane	37000	06HG29SO1	33	13	06H602GB	1	
Benzene, (1-methylethyl)-	710	06HG11SO1	[illegible]	18	06H603GB	2	
Cyclohexanone, 2,3-dimethyl-				16	06H603GB	1	
Benzene, propyl-				33	06H603GB	2	
Benzene, 1,2,3-trimethyl-	46800	06AMHSL05	8	57	06H604GB	3	
Indane	15600	06AMHSL05	5	31	06H604GB	2	
Benzene, 1-methyl-3-propyl-	29000	06HG11SO1	11	39	06H604GB	3	
Benzene, 1,2-diethyl-	320	06HG11SO2	1	42	06H604GB	2	
Benzene, 1-ethyl-2,3-dimethyl-	22100	06AMHSL03	6	28	06H603GB	1	
Benzene, 1-ethyl-2,4-dimethyl-	15000	06[illegible]09SO1	2	25	06H604GB	2	
Cyclohexane, propyl-	320	06HG11SO2	1	17	06H604GB	1	
Benzene, 1-methyl-2-(1-methyle	450	06H[illegible]1SO2	2	14	06H604GB	1	
Benzene, 2-ethenyl-1,3-dimethyl-				17	06H604GB	1	
1-Butanol				4.2	06H605GB	1	
Disulfide, dimethyl				7.9	06H604AS	1	
Benzene, 2-ethyl-1,3-dimethyl	1700	06H[illegible]SO1	1	2.5	06H605GB	1	
Novel for Soil:							
Undecane, 2,6-dimethyl-	21000	06HG29SO1	15				
Tridecane, 7-methyl-	[illegible]0000	06HG58SO1	6				
Tridecane	17000	06HG58SO1	26				
Heptylcyclohexanes	96[illegible]	06HG58SO2	5				
Tetradecane	23000	06HG58SO1	15				
Naphthalene, 1,4-dimethyl	3600	06HG57SO1	1				
Hexanedioic acid, bis(2-ethylh*	25000	06HG57SO1	1				
Benzene, 1,2,4,5-tetramethy*	31000	06HG09SO1	16				

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v est)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Novel for Soil:							
1,1'-Bicyclohexyl*	4900	06HG58SO1	2				
Tridecane, 4-methyl-	4200	06HG58SO1	1				
Tridecane, 2-methyl-	5200	06HG58SO1	2				
Tridecane, 3-methyl-	5700	06HG58SO1	1				
Naphthalene, 2,3-dimethyl-	6800	06HG58SO1	2				
Hexadecane	6700	06HG58SO1	5				
Benzene, 1,2,3,5-tetramethyl-	5800	06AMHSL05	6				
Cis-decalin, 2-syn-methyl-	7600	06HG58SO2	[illegible]				
Naphthalene, 2-methyl-	4000	06HG58SO2	3				
Nonane, 3,7-dimethyl-	7200	06HG58SO2	1				
p-Xylene	16600	06HG09SO1	6				
Benzene, 1,3,5-trimethyl-	40000	06HG09SO1	6				
Benzene, 1-methyl-4-(1-methyle*	20900	06HG58SO1	10				
Benzene, 1-methyl-4-propyl-	6280	06AMHSL03	[illegible]				
Benzene, 2-ethyl-1,4-dimethyl-	16000	06HG09SO1	14				
Benzene, 1,2,3,4-tetramethyl-	12000	06HG11SO1	9				
1H-indene, 2,3-dihydro-4-methy*	6600	06HG61SO1	7				
Indan, 1-methyl-	540	06H[illegible]1SO1	1				
Benzene, pentamethyl-	440	06HG09SO1	2				
1H-indene-1-one, 2,3-dihydro-*	580	06H[illegible]SO1	3				
Hexadecane, 2,6,10,14-tetrameth*	280	06HG61SO1	2				
3-Penten-2-one, 4-methyl-	[illegible]	06[illegible]56SO1	9				2
P,p'-dioctyldiphenylamine	8000	06HG10SO1	11				
Benzene, methyl (1-methyleth[illegible]	10000	06HG1[illegible]	3				
1-Phenyl-1-butene	3680	06AMHSL03	2				
Benzene, 1-methyl-3-(1-methyle*	9800	[illegible]HG58SO2	3				
Acetic acid	360	06HG27SO1	2				
Ethane, 1,1,2,2-tetrachloro-	[illegible]0	[illegible]HG65SO1	1				
Benzene, 1-methyl-2-propyl-	8000	06HG11SO1	3				
Dodecane, 4-methyl-	170	06HG65SO1	1				
Cyclohexane, 1,2,4-trimethyl-(1-*	5600	06HG57SO1	1				
1-Undecanol	5900	06HG57SO1	1				
Cyclohexene, 3-methyl-6-(1-methyl	7900	06HG57SO1	1				

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v [illegible]st)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Novel for Soil:							
Bicyclo[4.1.0]heptane, 3,7,7-trime*	5600	06HG57SO1	2				
1-Ethyl-2,2,6-trimethylcyclohexane	8800	06HG57SO1	4				
Cyclopentane, 1,3-dimethyl-2-(1-me	4600	06HG57SO1	1				
1-Isopropyl-1,4,5-trimethylcyclohe*	5400	06HG57SO1	1				
Cyclohexanecarboxylic acid, 4-pro	20000	06HG57SO1	1				
Sulfurous acid, butyl cyclohexylme	10000	06HG57SO1	1				
Cyclohexane, 1,1,4,4-tetramethyl-	6500	06HG57SO1	1				
o-Menth-8-ene	6200	06HG57SO1	1				
1,3-Cyclopentadiene, 1,2,3,4-tetra*	6100	06HG57SO1	1				
4-Methyl-dodecan-1-ol	5100	06HG58SO1	1				
Zinc, bis[2-1,1-dimethylethyl)-3,*	8900	06HG58SO[illegible]	3				
Hept-2-ene,2,4,4,6-tetramethyl-	8200	06HG58SO1	1				
Trichloroacetic acid, 1-cyclopenty*	7400	06HG58SO1	1				
Benzofuran, octahydro-6-methyl-3-(	4800	06HG58SO1	1				
Naphthalene, decahydro-2,6-dimeth	7500	06HG58SO1	6				
Benzene, 1,4-diethyl-2-methyl-	5100	06HG58SO1	1				
cis,cis-1,6-Dimethylspiro[4.5]deca*	4700	[illegible]58SO1	1				
Heptane, 3-ethyl-2-methyl-	17000	06HG29SO1	5				
Cyclohexene, 1-butyl-	108[illegible]	06HG[illegible]SO2	1				
Naphthalene, decahydro-1,1-dimeth	6000	06HG58SO2	1				
Octane, 4-methyl-	1400	[illegible]	3				
Pentafluoropropionic acid, 2-ethyl-	1400	06HG61SO1	1				
Octane, 3,3-dimethyl-	1500	06H[illegible]SO1	1				
Naphthalene, 1,2,3,4-tetrahydro*	1400	06HG61SO1	2				
Iodomethane	190	[illegible]HG63[illegible]	3				
2-Butanol, 3-(1-methyl-2-phenyleth	300	06HG63SO1	1				
Cyclohexene, 1-hexyl-	[illegible]580	[illegible]HG64SO1	1				
Hexane, 2,3,4-trimethyl-	13000	06HG11SO1	3				
Heptane, 4-(1-methylethyl)-	9[illegible]	06HG64SO1	1				
Decane, 3-methyl-	2000	06HG65SO1	4				
Cyclopentane, (2-methylbutyl)-	1000	06HG65SO1	2				
Cyclohexane, 1-methyl-4-(1-methyl	1100	06HG65SO1	2				
Cyclohexane, pentyl-	1700	06HG65SO1	3				

Appendix E: TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v est)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Novel for Soil:							
Cyclopentane, 1-butyl-2-ethyl-	350	06HG66SO1	1				
Tetracyclo[3.3.1.0(2,8).0(4,6)]-no*	1500	06HG66SO1	1				
Decane, 3,7-dimethyl-	350	06HG66SO1	2				
7-Methoxymethyl-2,7-dimethylcycl(	600	06HG66SO1	1				
Hexadecane, 1-chloro-	570	06HG66SO1	1				
Hexane, 2,2,4-trimethyl-	260	06HG71SO1	1				
Methyl acetate	250	06TB71	1				2
Cyclotetrasiloxane, octamethyl-	1700	06HG13SO1	[illegible]				
Carbon dioxide	21000	06HG11SO1	7				
5-Octadecene, (E)-	540	06HG10SO2	1				
Cyclohexane, 1,2-diethyl-3-methyl	2000	06HG10SO2	1				
Cyclohexane, 1,4-dimethyl-, trans-	2300	06HG10SO2	1				
Undecane, 2,6-dimethyl-	930	06HG10SO2	1				
Bicyclo[4.1.0]heptane, 3-methyl-	710	06HG10SO2	1				
Benzene, 1,4-diethyl-	23000	06HG11SO1	2				
1H-Indene, 2,3-dihydro-5methyl	10000	06HG11SO1	2				
Heptane, 3-ethyl-2-methyl-	1100	06HG11SO2	1				
Ethyl acetate	160	06H[illegible]3SO1	3				
Tetrahydrofuran	67	06HG12SO1	3				
trans-1,4-Dichloro-2-butene	840	06H[illegible]SO2	2				
Benzoic acid, 2-[(trimethylsilyl)o	710	06HG12SO2	3				
Cyclopentane	20[illegible]	06HG39SO1	5				
Sulfamide	350	06HG10SO1	2				
Bicyclo[2.2.1]heptane, 2-buty[illegible]	330	06HG1[illegible]	1				
1-Pentene, 2,3-dimethyl-	570	06HG10SO1	1				
4-Octene, 2,3,6-trimethyl-	270	06HG10SO1	1				
Oxirane, (3,3-dimethylbutyl)-	430	06HG10SO1	1				
2H-Pyran, tetrahydro-4-methyl-2-(2	[illegible]	06HG10SO1	1				
1-Isopropyl-1,4,5-trimethylcyclohe	2200	06HG10SO1	1				
Cyclohexanone, 2-methyl-5-(1-meth	1100	06HG07SO1	2				
Bicyclo[2.2.1]heptane, 2,2,3-trimeth	370	06HG10SO1	1				
1-Methyldecahydronaphthalene	1900	06HG29SO1	4				
Phosphoric acid, tris(methylphenyl)	190	06HG10SO1	1				

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v [illegible]st)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Novel for Soil:							
Nonane, 2-methyl-3-methyene-	100	06HG10SO2	1				
Benzene, 1,2-dimethyl	1700	06HG11SO2	2				
Benzene, (1-methyl-1-propenyl)-	260	06HG11SO1	1				
Phenol, 2,3-dimethyl	260	06HG11SO1	1				
Benzoic acid, 2-methyl	290	06HG11SO1	[illegible]				
Benzoic acid, 3-methyl	270	06HG11SO1	1				
Benzoic acid, 2,5-dimethyl	200	06HG11SO1	1				
4-Methylbenzoic acid	220	06HG11SO1	1				
Benzoic acid, 3,5-dimethyl	210	06HG11SO1	1				
Benzene, (1-methylpropyl)-	520	06HG11SO2	1				
Benzene, 4-ethyl-1,2-dimethyl-	510	06HG11S[illegible]	1				
Benzene, 2-butenyl-	440	06HG11SO2	1				
3-Eicosyne	140	06HG12SO2	1				
Benzo[b]fluoranthene	25	06HG13SO1	1				
Benzo[k]fluoranthene	6.7	06HG11SO1	1				
1,4-Benzenediol, 2-[(1,4,4a,5,6,7,	240	06HG11SO1	1				
cis-1,4-Dimethylcyclohexane	2970	06[illegible]HSL03	1				
3-Methylheptane	1900	06AMHSL03	1				
4-Propylheptane	2200	06A[illegible]HSL03	1				
O-Decylhydroxylamine	2540	06AMHSL03	1				
Trifluoromethylbenzene	475	[illegible]AMHS[illegible]	1				2
2,6-Dimethylheptane	467	06AMHSL04	1				
2-Methyl-1-pentanol	5320	06A[illegible]SL05	1				
2-Ethyl-1,4-dimethylbenzene	5090	06AMHSL05	3				
2,6-Dimethylundecane	4080	[illegible]6AMHS[illegible]05	6				
Decahydronaphthalene	88	06HG02SO1	1				
1,2,4-Trimethylbenzene	[illegible]300	[illegible]AMHSL03	2				
1-Ethyl-4-methylbenzene	16500	06AMHSL05	2				
4-Methyldecane	61[illegible]	06AMHSL05	2				
2,5,5-Trimethyl-2-hexene	231	06AMHSL04	1				
1,1-Dimethylethyl acetic acid	526	06AMHSL04	1				
4-Octyl-N-(4-octyl) benzenamine	6660	06AMHSL04	1				
2,6,11-Trimethyl dodecane	237	06AMHSL04	1				

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v est)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Novel for Soil:							
1,1,2,2-Tetrachloro ethane	470	06HG27SO1	4				
Heptanoic acid, anhydride	232	06AMHSL04	1				
2,6,10,14-Tetramethylhexadecane	244	06AMHSL04	1				
Pentadecane	283	06AMHSL04	1				
2,6,10,14-Tetramethyl pentadecane	281	06AMHSL04	1				
2,6-Dimethyloctane	2910	06AMHSL05	1				
Eicosane	160	06HG01SO1	2				
alpha-1-Naphthalenepropanol	330	06HG02SO1					
Heneicosane	160	06HG02SO1	1				
2,6,10,15-Tetramethylheptadecane	470	06HG04SO1	1				
2,6,10,14-Tetramethylpentadecane	270	06HG04SO1	1				
Toluene	180	06HG05SO1	2				
1,4,5,6,7,7a-h 2H-inden-2-one	820	06HG08SO1	1				
1,3,4-Trimethyladamantane	220	06HG08SO1					
2-Butyl-1,1,3-trimethylcyclohexane	800	06HG08SO1	1				
(1-methylethyl) benzene)	1900	[illegible]HG09SO1	1				
1H-Indene, 2,3-dihydro-4-methy	200	06HG09SO1	1				
2-Methylnaphthalene	390	06H[illegible]9SO1	1				
1,3-Dimethylbenzene	20000	06HG09SO1	1				
1-Ethyl-3-methylcyclohexane	13000	06H[illegible]SO1	1				
Cyclohexanone, 5-methyl-2-(1-M*	2400	06HG29SO1	1				
N-Amylcyclohexane	[illegible]	06[illegible]29SO1	1				
Spiro[5.5]undecane	1000	06HG29SO1	1				
Decane, 2-methyl-	440	06HG3[illegible]	1				
Benzocycloheptatriene	96	06HG30SO1	1				
Acetic acid, methyl ester	120	[illegible]HG53SO1	5				
Naphthalene, decahydro-	78	06HG32SO1	1				
Ethanol, 2-(tetradecyloxy)-	[illegible]0	[illegible]6HG32SO1	1				
Bicyclo[4.3.1]decan-10-one	250	06HG40SO1	1				
1-Ethyl-2,2,6-trimethylcyclohe*	390	06HG54SO1	2				
Naphthalene, 1-isocyano-	330	06HG41SO1	1				
1-Octanol, 2-butyl-	280	06HG41SO1	1				
3-Dodecene, (Z)-	100	06HG41SO1	1				

Appendix E. TENTATIVELY IDENTIFIED COMPOUNDS1	Highest Soil Conc (ppb)1	Sample w/ highest soil value	# samples detected (out of 70 samples)	Highest Soil Gas (ppb v/v est)1	Sample w/ highest soil gas value	# samples detected (out of 30 samples)	Notes
Novel for Soil:							
Undecane, 3,6-dimethyl-	210	06HG41SO1	2				
Cyclohexane, 2-butyl-1,1,3-tri*	250	06HG54SO1	3				
Octane, 3,6-dimethyl-	430	06HG54SO1	3				
Decane, 2,3,7-trimethyl-	60	06HG45SO1	1				
Octane, 3-ethyl-	47	06HG50SO1					
6-Tridecene, 7-methyl-	85	06HG55SO1	1				
Nonane, 3-methyl-	59	06HG56SO1	1				
Heptadecane	70	06HG56SO1	1				
Diisooctyl adipate	32000	06HG29SO1	1				
Nonanedioic acid, bis(2-ethylh*	6500	06HG29SO1	1				
Ethanol, 2-[2-(2-methoxyethoxy*	200	06HG41SO1	1				
Ethanol, 2-[2-(2-butoxyethoxy)*	690	06HG41SO1	1				
3,6,9,12-tetraoxahexadecan-1-o*	240	06HG41SO1	1				
Pentacosane	350	06HG44SO1	1				
Decane, 5-propyl-	190	06HG45SO1	1				
M-terphenyl	2400	06HG53SO1	2				

1=Tentative identifications are based on retention time and mass spectral data, and are not confirmed with standards
Concentrations are gross estimates, and assume similar response factors relative to targeted analytes
2=Analyte also detected in Method Blank

Appendix F: Description of Screening Criteria

In Appendices C and D, the concentrations of chemicals detected in soil, soil gas and water are compared to various screening values. Each of these screening values is described briefly below.

EMEG: EMEG is an ATSDR-derived comparison value called an Environmental Media Evaluation Guide. EMEGs are estimated contaminant concentrations that are not expected to result in adverse noncarcinogenic health effects based on ATSDR evaluation. EMEGs are based on ATSDR MRLs and conservative assumptions about exposure, such as intake rate, exposure frequency and duration, and body weight.

EMEGs can be established for three different exposure frequencies: **Acute** is 14 days or less, **Intermediate** is 15 – 364, and **Chronic** is 365 days or longer.

RMEG: RMEG is an ATSDR-derived comparison value called a Reference Dose Media Evaluation Guide. ATSDR derives RMEGs from EPA's oral reference doses, which are developed based on EPA evaluation. RMEGs represent the concentration in water or soil at which daily human exposure is unlikely to result in adverse noncarcinogenic effects.

Reference Dose (RfD): A reference dose is an EPA-derived comparison value for a chemical. The RfD is an estimate of an oral exposure, for a given duration, to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.

Reference Concentration (RfC): The inhalation reference concentration is an EPA-derived comparison value. The RfC is an estimate of an inhalation exposure, for a given duration to the human population (including susceptible subgroups) that is likely to be without an appreciable risk of adverse health effects over a lifetime.

NIOSH REL: A recommended exposure limit (REL) is an occupational exposure limit that has been recommended by the National Institute for Occupational Safety and Health (NIOSH) to the Occupational Safety and Health Administration (OSHA) for adoption as a Permissible Exposure Limit (PEL). The REL is a level that NIOSH believes would be protective of worker safety and health over a working lifetime if used in combination with engineering and work practice controls, exposure and medical monitoring, posting and labeling of hazards, worker training and personal protective equipment.

Appendix G: Evaluation of USACHPPM Risk Assessment Assumptions, and a Reprint of the Report's Conclusions

Evaluation of Assumptions

In accordance with standard risk assessment practice, USACHPPM used assumptions for various parameters involved in calculations of estimated chemical exposures and risks. Here, ADPH compares USACHPPM assumptions against default ATSDR guidance (ATSDR 2005).

Table G1: List of Exposure Pathway Assessment Values for Various Parameters: A Comparison of USACHPPM and ATSDR default values

Pathway	Parameter	USACHPPM	ATSDR
Common Values	Exposure Duration	1 year	
	Exposure Frequency	180 days/year	
	Averaging Time (noncarcinogenic)	1 year	
	Averaging Time (carcinogenic)	70 years	
	Body Weight - adults	70 kg	70 kg
Soil Ingestion	Ingestion Rate	[illegible] mg/day	100 mg/day
	Fraction Ingested	1.0	
Dermal Absorption (soil)	Surface Area (head, arms, & hands)	3300 cm^2	4656 cm^2
	Conversion Factor	1E-6 kg/mg	
	Adherence Factor	0.[illegible] mg/cm^2	0.07 mg/cm^2
	Absorption Factor	Chem. Specific	
Ambient and Soil Gas Inhalation	Inhalation Rate	20 m^3/day	15.2 m^3/day
	Exposure Time	12 h/day	

In general, the assumptions that USACHPPM used in their risk assessment were consistent with ATSDR guidelines, or were overly conservative (i.e., worst-case assumptions that over-estimated potential health effects). For example, USACHPPM evaluated sub-chronic exposure risks rather than simply the acute risk, with an exposure duration of one year, and a frequency of 180 days/year. This assumed exposure is obviously an overestimate of the actual exposures that occurred during this two-day incident. Risks from exposure to soil were conservative, with a higher ingestion rate and adherence factor than ATSDR typically assumes. These conservative assumptions more than compensate for a smaller assumed exposed surface area of the skin (3300 cm^2 assumed by USACHPPM compared to 4656 cm^2 assumed by ATSDR).

Since the air inhalation pathway is the most likely exposure pathway during this incident, it is a critical part of their risk assessment. USACHPPM was conservative in their selection of an inhalation rate (20 m^3/day in comparison to 15.2 m^3/day used by ATSDR), and an exposure time of 12 hours per day.

USACHPPM evaluated the risk of chronic health effects such as cancer, rather than the risk of acute health effects. Chronic health effects can be elicited by much lower levels of chemicals than are required to produce acute health effects. None of the chemicals measured were present at levels that could cause acute health effects, as determined by comparison with screening values when available. While the evaluation of chronic health risk was important in the context of USACHPPM's charge, which was to ascertain the safety for future construction work at the site, it is an overly conservative approach for the evaluation of acute health risk.

In summary, it is ADPH's opinion that USACHPPM used appropriate, conservative assumptions to calculate human health risks in their report.

The USACHPPM report's conclusions are reprinted here as a convenience for the reader, as the USACHPPM report may not be readily available to the public. They are as follows:

a. This Center conducted a comprehensive occupational and environmental health risk assessment on all of the environmental sampling data collected from the exclusion site of Hangar 6 between 29 June and 23 October 2006. Based on an extensive scientific and professional analysis of the environmental sampling data, the health risk assessment did not show an unacceptable health risk, which, therefore indicates it is safe for workers to re-enter the exclusion site to finish construction activities.

b. Assessing the risk for acute exposures was not conducted because all concentrations for soil, air, and soil vapor were well below exposure limits that would cause any acute illnesses. The next step was to assess potential long-term health risks. The risk assessment used very conservative chronic (long-term) toxicity values with exposure assumptions to address the likely worst-case exposure scenario based on the data collected for soil and air.

c. To date, the specific chemical hazards that workers may have been exposed to on 29 and 30 June 2006 have not been determined. The team of experts from this Center and the Garrison Command in charge of assessing the health risk findings in this report are genuinely concerned with the heatlh and welfare of all those involved with current and future construction activities on the exclusion site of Hangar 6. The Garrison Command is taking every precaution to ensure the safe (sic) and well-being of all personnel working on current and future construction projects at Fort Wainwright, Alaska.

d. The major supporting facts for this conclusion are:

(1) The contaminated soil of concern was removed and there should be no health issues for remaining measured contaminants for current and future construction activities on the exclusion site.

(2) Anticipated future construction activities will avoid or minimize excavating or trenching of the remaining area that is not backfilled.

(3) The combined hazard quotient for the exclusion site including soil ingestion, dermal absorption, and inhalation of ambient air, is 0.7. To indicate a potential non-carcinogenic hazard, this number would need to exceed 1.0.

(4) The combined cancer risk estimate for the exclusion site including soil ingestion, dermal absorption, and inhalation of ambient air, if 9.5E-7. This is well below the upper bound of 1.0E-4 and indicates there is not an unacceptable excess cancer risk.

(5) The ambient air sampling data were well below occupational exposure limits and environmental screening levels.

(6) Confirmation sampling after the soil removal action indicated that several target compounds were reduced to non-detect levels.

Reprinted with permission from the Garrison Commander, Fort Wainwright, Alaska