ATSDR Agency for Toxic Substances & Disease Registry Public Health Assessments & Health Consultations

HEALTH CONSULTATION

Environmental Pathway Evaluation for Beryllium and Depleted Uranium

IOWA ARMY AMMUNITION PLANT
MIDDLETOWN, DES MOINES COUNTY, IOWA

BACKGROUND AND STATEMENT OF ISSUES

The Agency for Toxic Substances and Disease Registry (ATSDR) is required by provisions ofthe Comprehensive Environmental Response, Compensation, and Liability Act to prepare publichealth assessments (PHAs) of hazardous waste sites either proposed for, or listed on, theNational Priorities List (NPL). The Iowa Army Ammunition Plant (IAAAP; originally calledIowa Ordnance Plant) was added to the NPL in August 1990 and in 1999 the PHA was prepared,as required (ATSDR 1999). Prior to the release of the PHA, information became available aboutthe use of radioactive materials at certain locations within the IAAAP that were under thejurisdiction of the Atomic Energy Commission (AEC) during the interval from 1947 to July1975.

Concerns were raised by members of the public and public officials regarding the presence ofradioactive material and the potential for residual radioactivity that may affect the health of bothworkers and residents of nearby communities and farmlands. ATSDR released the 1999 PHA,which evaluated the potential heath effects resulting from environmental releases of explosivesand other substances, and included a recommendation that, when sufficient information becameavailable, ATSDR prepare another document concerning the possible presence of radioactivematerials at IAAAP.

In 2000, ATSDR received historical memoranda, letters and other documents for the 1947-1975time-interval from the Army and obtained draft results of an indoor radiological survey from theDepartment of Energy (ORNL 2001). Following a review and evaluation of that information,ATSDR prepared a public health consultation (ATSDR 2001). That consultation concluded that,at that time, there was insufficient information available to determine the potential public healtheffects of the site. The consultation recommended additional environmental surveys andsampling to more fully characterize the extent of radiological contamination, including depleteduranium (DU), at Line 1 and Firing Site 12.

Following the release of the ATSDR (2001) consultation, additional data and information weregathered and released for review and evaluation. Health concerns have focused on releases andexposure to beryllium (Be) and DU and the potential effects those substances may have had onworkers or the community members.

ATSDR has reviewed and evaluated the information now available to determine the potentialpublic health effects that may relate to the use and presence of those substances at IAAAP. Thispublic health consultation will focus on the public health concerns about potential *environmentalreleases* and subsequent human exposure to Be and DU. ATSDR does not evaluate occupationalexposures. For each of the concerns addressed below, ATSDR has evaluated potentialenvironmental pathways

of exposure to the community and the potential health consequencesthat may arise from those exposures. A statement of each public health concern is followed bythe *conclusions* that can be drawn at this time and a *discussion* which summarizes the information supporting those conclusions.

Site Description

The IAAAP is a totally fenced and secured, operational, government-owned and contractor-operated facility located on approximately 19,100 acres in Des Moines County, southeasternIowa (Fig. 1). The Plant, located adjacent to Middletown, Iowa and about six miles west ofBurlington, Iowa, is surrounded by rolling prairie with mixed agricultural uses and numerousrural residences (JAYCOR 1996).

The topography of IAAAP is generally flat to gently rolling terrain dissected by shallow, south-to southeast-draining stream channels. The area groundwater also migrates generally to thesoutheast. The prevailing winds are usually from the west.

Surface water drainages in the Line 1 area flow to Brush Creek on the west side of the Linewhich then flows southward to its confluence with Skunk River. Surface water drainages in theFiring Site (FS) Area are tributary to Long Creek. Mathes Lake lies along the course of LongCreek and is located near the center of IAAAP; about 1000 feet from the northeast perimeter.

Prior to 1977, water drawn from Mathes Lake and treated in an onsite treatment plant providedthe primary drinking water supply for IAAAP. After 1977, drinking water was supplied from theCity of Burlington, Iowa Municipal Water Works.

Since load, assemble, and packaging operations began in 1941, IAAAP has used explosives andlead-based initiating compounds to produce a wide variety of ordnance items. The operator ofIAAAP (American Ordnance LLC) is currently licensed by the Iowa Department of PublicHealth License Number 0290-1-29-SM1 for "assembly and demilitarization of staballoy[1] DUpenetrators in munitions assemblies and for research and development as described in theapplication to the Nuclear Regulatory Commission (NRC) dated October 6, 1993." Employeeinterviews and records searched and reported by TN & Associates (TNA 2002) indicate that DUdemilitarization activities at IAAAP may have begun as early as 1975. Interviews further detailthat, after Operation Desert Storm, DU rods may have been removed from 120mm anti-armortank rounds in Line 1, Building 1-85-2.

In 1947 the Line 1 area, portions of the Firing Site (FS) area, the Explosive Disposal Area(EDA) sites, and Yards C, G, and L came under the jurisdiction of the former Atomic EnergyCommission (AEC). The Security Command Center (SECOM), the Emergency ResponseCommand Post (ERC), the Deactivation furnace, Line 3 Warehouse 301, and the North BurnPads Landfill may have also been utilized. Those areas, totaling perhaps 1,630 acres, becameknow as the Burlington Atomic Energy Commission Plant (BAECP; COE 2001). Both Be andDU were used in the manufacture or assembly of the finished weapons at Line 1. Components ofthe devices or compounds were tested at the FS areas. BAECP continued operations at thosesites until July 1975. After conducting various site clean-up activities, the jurisdiction of thosesites was returned to the Army (COE 2001).

Line 1 (Fig. 2) is approximately one mile long and occupies about 170-190 acres. Line 1encompasses 250 buildings and related facilities that were all apparently used in some manner insupport of the operations related to the fabrication and installation of the shaped chargessurrounding the core of the nuclear weapons. IAAAP then partially disassembled the completedweapons for shipping to off-site storage facilities (TNA 2002).

The Firing Site (FS) area (Fig. 2) comprises about 450-500 acres and was developed for testingexplosives and ammunition. Operations at the FS were centered on the South Firing Site (FS-6)and the North Firing Site (FS-12). FS operations were supported by 15 structures includingadministrative buildings, storage magazines, component assembly facilities, and observationbunkers.

The EDA is comprised of the East and West Burn Pad areas. Those areas were remediated bysoil and ash removal from 1998 to 2000 and are reported to presently represent a low potentialfor contamination (COE 2001). Within the EDA, the East Burn Pad site was utilized, prior to1982, for purposes that included the burning or flashing of explosives-contaminated metal,including DU, to remove the explosives residue (COE 2001). There is a possibility that not all ofthe potentially DU-contaminated ash was removed and residual ash may contribute to surfacewater and groundwater contamination. ATSDR does not, at this time, have sufficient informationto fully evaluate the EDA, although some conclusions can be drawn.

Insufficient data are available at this time to more fully evaluate the Storage Yards C, G, and L,the Deactivation Furnace, Warehouse 301, and the North Burn Pads Landfill. Although thepotential for contamination at those locations is judged to be low, the COE (2001) plansadditional investigations at these sites. There is no evidence of releases at the SECOM and ERCand no further evaluation of these sites is planned (COE 2001).

COE (2001) concluded that additional investigations of various environmental media (i.e.groundwater, surface soils, and sediments) are needed and are planned to fully characterize thelocation and degree of environmental contamination at Line 1 and the FS area.

During October 2002, a low-level flyover was conducted to detect evidence of DU or otherradiologic contamination at IAAAP and a 500-foot wide swath outside of the Plant boundaries.The results of the flyover were released in April 2003. Those results will be discussed in thesection of this public health consultation dealing with the evaluation of potential environmentalreleases of DU at BAECP. Additional site investigations are planned for Fiscal Year 2004(Cotner, personal communication 2002).

Although all planned investigations have not been completed, the additional information that hasbecome available since the release of the ATSDR Health Consultation (March 19, 2001) makesit possible to provide additional evaluation of the potential for exposure of plant workers and nearby residents to environmental releases of Be and DU.

Beryllium: Its Characteristics and Uses

Beryllium is a naturally occurring, silver-grey metal. Lighter than aluminum and more rigid thansteel, Be has many unusual properties which make it ideal for several applications, includingaircraft and space vehicle structure, x-ray machine assemblage, mirrors, ceramics, metal alloys,and, since the 1950's, nuclear technology including weapons and reactors.

The most significant disadvantage of Be as an industrial material appears to be the toxicity of itsdust, fumes, and soluble salts. However, metallic Be has good resistance to alteration orchemical attack and is not easily altered to soluble forms when released to the environment.Most Be in the soils does not dissolve in water and remains bound to the soil particles (ATSDR2002a, b).

Beryllium is used as the reflector material (or 'pit liner') in most American nuclear weapons andin contemporary thermonuclear 'primaries'. The 'primary', or weapon trigger, consists of threecomponents: the central spherical plutonium 'pit' or core, the Be 'pit liner', and a

surroundinghigh-explosives shaped-charge.

Depleted Uranium: Its Characteristics and Uses

Uranium, the source material for depleted uranium, is a silver-white, lustrous, dense, slightlyradioactive element. Natural uranium consists of a mixture of three radioactive isotopes: U-238(about 99.27% by mass), U-235 (about 0.72%), and U-234 (about 0.0054%). Uranium is presentthroughout the natural environment in rocks, soil, water, air, plants, animals, and in all humans(WHO 2001a). Because uranium is found in the environment in trace amounts, people can intakeit into their bodies via air, food, soil, and water. Uranium contributes to a natural level ofradiation in our environment, called background radiation (ATSDR 1999c).

Depleted uranium is a byproduct of the process by which uranium is enriched to produce nuclearreactor fuel and nuclear weapons components. The leftover uranium, DU, by definition, is 40%less radioactive than natural uranium. The DU remaining after removal of the enriched fractionis comprised of about 99.8 % U-238, 0.2% U-235, and 0.0006% U-234 by mass. Reprocessingthe uranium in spent nuclear fuel may result in DU containing very small amounts of U-236,plutonium, americium, neptunium, fission products including cesium-137 and technetium-99.These radio-isotope contaminants in the DU would result in an increase in the radiation dose from uptake in the human body by less than 1% (WHO 2001a).

Depleted uranium is produced in large quantities in the process of enriching uranium and, thus,is widely available and inexpensive to use for a wide variety of civilian and military uses. It is aheavy metal and is twice as dense as lead (Harley et al. 1999). This density provides its value foruse in civilian and military applications. The main civilian uses of DU include counterweightand control surface applications in some aircraft, counterweights in some elevators, radiationshields in medical radiation therapy machines, and containers for the transportation ofradioactive materials. Military applications include the use in armor piercing munitions and armor plate for military vehicles such as tanks.

STATEMENT OF ISSUES

The following public health issues or concerns about potential releases of beryllium (Be) and depleted uranium (DU) are the focus of this Public Health Consultation.

Concerns:

Have there been environmental releases of beryllium (Be) from industrial operations atBAECP or elsewhere at IAAAP? If environmental releases have occurred, have workersor community members been exposed to Be at levels that would harm their health?

Conclusions:

- Based upon available evidence, there has been no release of Be to theenvironment at IAAAP. The background levels of naturally occurring Be found insurface soils are not of health concern.
- The source of Be contamination at BAECP was likely associated with the sandingor machining of Be components, or from Be dust found on incoming components.This contamination was detected in samples of interior dust, but is not detected inenvironmental samples.
- In the past there was a slight potential for incidental worker ingestion orinhalation

of naturally occurring Be in dust or soil particles. The levels ofnaturally occurring Be detected in the surface soils were and are below levels ofhealth concern and would not result in harm to workers' health.

- ATSDR concludes that the uses of Be at BAECP did not represent anenvironmental health hazard to the nearby communities and residents, includingformer occupants of the on-post residential area.

Discussion:

During the nuclear weapons assembly process at BAECP, machining and sanding operations ofthe explosives castings and the Be 'pit liners' (sometimes referred to as 'skulls', or 'helmets')were performed to ensure a proper fit for the final assembly of the weapons. It was this Besanding process that was, at least in part, responsible for the release of Be dust into the indoorenvironment of the buildings dedicated to this aspect of the process. Figure 3 provides ageneralized, diagrammatic cross-section of a spherical nuclear weapon core showing the relativepositions of the components.

ATSDR reviewed the 1970-74 results of Be wipe tests conducted by the BAECP DevelopmentDepartment. The wipe tests were used to detect the presence of Be contamination on indoor,environmental surfaces. Presence of that contamination could suggest potential occupationalexposure to Be in the buildings at Line 1 where sampling was conducted and may also suggestpotential locations where accidental releases of Be to the environment could have occurred (seeTable 1).

In addition to individual sample results recorded in those analytical reports from August 1970thru August 1974, summary observations were offered that Be levels were highest near thesanding and case areas. Additionally, wipe sampling data prompted the following observation:

> "It is probable that much of the beryllium contamination observed is due to the berylliumdust on incoming component parts which were not adequately cleaned prior to shipmentand not from the small sanding operation conducted at the Burlington AEC Plant."(Shahan 1971).

Regardless of the sources of Be contamination, the locations of indoor Be contaminationsuggests the sites of potential Be releases to outdoor surface soils and possibly to the air nearaffected buildings. In locations where those surface soils can be eroded by running water fromrainfall or historical industrial effluent wastewater, there is also the potential for transportation ofthe Be contamination to nearby ditches or water bodies.

In the process of collecting data needed for the preparation of the IAAAP RemedialInvestigation (RI) report, numerous surface soil samples (0-1-ft depth) were collected andanalyzed for a variety of constituent elements and compounds by JAYCOR (1996). Of that total,Be was detected in surface soils (0 -1 ft.) at low levels in about 158 samples collected in the Line1 area and in 13 samples collected in the FS area. The highest level of Be detected in the Line 1area was 3.15 mg/kg in surface soils northwest of Building 1-99-5. In the FS area the highest Bedetection was 2.36 mg/kg found about 100-feet west of the FS-12 pad. As discussed in the DataEvaluation section, the maximum Be background level was found to be 1.72 mg/kg (TNA 2002).

Subsequent to the JAYCOR investigation, TNA was selected to prepare a Line 1 and Firing SiteSupplemental RI for IAAAP. During the process of preparing the Supplemental RI, Be wasdetected at low levels in about 170 surface soil (0-1 ft.) or drainage ditch (0-1 ft.) samples (TNA2002). The highest Be-level detected was 1.91 mg/kg in a drainage ditch east of Building 1-50.

Data Evaluation

About 107 surface soil sample samples were collected by JAYCOR (1996) throughout IAAAPin areas less likely to have been impacted by Plant activities. These samples were collected todetermine the natural level (*background level)* of metals, including Be, in the surface soils of thearea. Subsequent background surface soil sampling was conducted by TNA (2002) to validatethe JAYCOR results and to further evaluate the surface soils to ensure that the background levelsdetermined by the JAYCOR investigation accurately characterized the background levels ofmetals in IAAAP surface soils (0-1.5 ft. depth). Through this process the maximum Bebackground level was determined to be 1.72 mg/kg (TNA 2002).

Shaklette and Boerngen (1984) reported the average and range of Be concentrations in soils andother surficial deposits in the conterminous United States as 0.63 mg/kg and <1 to 15 mg/kg,respectively. Thus, the maximum background level determined at IAAAP falls in the lower endof the range of Be background values recorded throughout the U.S.

The background levels of naturally occurring metals in the environment set benchmark levels fordetecting the presence of contaminants in the environment. In this case, Be levels detected insurface soils that are above the local, maximum-background level for Be, may be the result ofthe environmental releases of Be from activities that occurred in BAECP or IAAAP facilities.

A review of the Be analytical data compiled by JAYCOR reveals only 5 detections in the Line 1area above the maximum-background level (1.72 mg/kg). Those Line 1 detections ranged from1.8 to 3.15 mg/kg. In the FS area, only one surface soil detection (2.36 mg/kg) was found abovethe maximum background level.

Similarly, a review of the Be analytical data compiled by TNA reveals only one surface soildetection (1.91 mg/kg, noted above) in excess of the maximum reported background value.

Table 2 provides a summary of the values and locations of the seven surface soil samples thatyielded Be concentrations greater that the maximum background value.

In planning their investigation, TNA reviewed site historical records and the data amassed byJAYCOR to determine areas of potential concern. The TNA sampling locations were selected toconfirm any elevated levels of metals or explosives reported in the JAYCOR RI (1996). Asshown above, the results reported by JAYCOR included a few more samples with values greaterthan the maximum background value.

The records show that many of the JAYCOR surface soil samples were collected around formersump areas. Those sump areas sampled by JAYCOR were determined to have contaminantcontents for various compounds that were above preliminary remediation goal-levels and weresubsequently excavated (TNA 2002). Thus, when the same general areas were sampled duringthe TNA investigation, it appears that the most contaminated soils had been removed. The TNAsampling results seem to reflect the minor level of potential Be contamination not directlyrelated to former sump areas. The Be levels recorded by the JAYCOR sampling are so low that itis difficult to conclude that those samples indicated environmental releases of Be to the sumps.

The locations of the Be detections in the surface soils of the Line 1 and FS areas do not point toclear-cut sources of environmental releases of the element by Plant activities. Rather, the soilsdata strongly suggest that Be dust or contamination was contained within the buildings or byvarious safeguard measures that may have been employed at the time.

The levels of Be found in surface soils are not of health concern.

The maximum levels of Be detected in theJAYCOR RI studies are only slightly elevatedabove the natural background level. Thelocations sampled do not suggest any potentialareas or "hot-spots" of Be contamination. Thus, *ATSDR concludes that, in the past, there was aslight potential for incidental worker ingestion of naturally occurring Be in dust or soil particles.The levels of Be detected in those soils were and are below levels of health concern and wouldnot result in harm to worker's health.* Incidental oral ingestion of Be-contaminated dust or soilfrom IAAAP would result in a dose several orders of magnitude below the 1 µg/kg/day MinimalRisk Level (MRL) derived by ATSDR (2002a). The MRL is an ATSDR estimate of dailyhuman exposure to a hazardous substance at or below which that substance is unlikely to pose ameasurable risk of harmful (adverse), noncancerous effects.

Lacking any evidence of transportation of Be from a Line 1 or Firing Site area source tolocations near the IAAAP boundaries, *ATSDR concludes that the uses of Be at those locationsdid not result in any significant environmental releases of the element and do not represent anenvironmental health hazard to the nearby communities and residents, including formerresidents of the on-post living area.*

Concern:

Have workers or community members been exposed to environmental releases ofdepleted uranium (DU) at levels that would harm their health?

Conclusions:

- The evidence available at this time does not indicate that environmental releasesof DU occurred from BAECP activities conducted at Line 1.
- The opportunity for human exposure to infrequent and minor environmentalreleases of DU at FS-6 was extremely limited and does not represent a healththreat.
- The localized environmental release of DU-bearing dust and fragments duringhydroshot testing or subsequent remediation activities at FS-12 have not resultedin any exposure to the nearby communities or residents, including the formerresidents of the on-post residential area.
- During the 1965-1975 interval there was a limited opportunity for incidental,inhalation exposure of workers to DU-bearing dust in close proximity to FS-12immediately following the detonation of a hydroshot. Subsequent site clean-upactivities may have re-suspended some DU particles and some incidental,inhalation exposure of remediation workers may have occurred.
- There is a limited potential for incidental, inhalation exposure to DU for workersinvolved in munitions testing or site maintenance at FS-12 during the intervalfrom 1975 until 2000.
- Burning or flashing of explosives-contaminated DU at the East and perhaps theWest Burn Pads did not create an air pathway of exposure for nearbycommunities or residents, including the former residents of the on-post residentialarea.
- Vegetation in the Burn Pads area would not have been contaminated with DU andany subsequent burning of the vegetation would not contribute to airborne DU.

Discussion:

Exposure to DU: Potential Health Effects

Because of the many similarities between naturally occurring uranium and DU, many of the findings on the potential health effects from human exposure to uranium are also useful to more

fully understand the potential effects that might arise from exposure to DU. Furthermore, because of uranium's chemical properties, the adverse health effect associated with its exposure is one of a heavy metal, that is, its effect on the kidneys. ATSDR (1999b) has derived a Minimum Risk Level (MRL) for oral ingestion of uranium of 2 µg/kg/day and an inhalation MRL of 8 µg per cubic meter in air.

On the average, about 90 µg of uranium exist in the human body from normal intakes of water, food, and air. The average intake of uranium by adults is estimated to be 460 µg from ingestion and 0.59 µg from inhalation. Most (>95%) of the uranium entering the body by ingestion or inhalation is not absorbed by the body, but is eliminated in the feces. Of the uranium that is absorbed in the blood, approximately 67% will be filtered by the kidneys and excreted in the urine within 24-hours; this amount increases to about 90% in a few days. Typical gut absorption rates for uranium in food and water are about 2% for soluble uranium compounds and about 0.2% for insoluble uranium compounds (WHO 2001a).

No human cancer of any type has ever been demonstrated to be a result of exposure to uranium or DU (ATSDR 1999b).

Long-term studies of uranium miners have reported some impairment of kidney functiondepending upon the level of exposure. There is someevidence, however, that this impairment may betransient and that kidney function returns to normal afterthe exposure to elevated levels of uranium has ceased(WHO 2001a). In other studies of uranium miners, anincreased risk of lung cancer has been reported, but thishas been attributed to exposure to radon decay products and lung irritants present in the mines.

In recent years, extensive and intensive national and international investigations have beenconducted on the potential human health effects that may arise from civilian exposure resultingfrom the production, storage, or uses of DU, as well as to exposure that may result from militaryapplications of DU-bearing ordnance on the battlefields such as the Balkans, Kuwait, and Iraq.Excellent, comprehensive overviews of those investigations on potential human health effectsare summarized in sources such as the WHO DU monograph and fact sheet (WHO 2001a, b) orin U.S. Defense Department informational papers or exposure reports on DU (see DOD 2000,2001).

Concerns about potential health effects have been voiced by some military veterans that wereeither exposed to DU by friendly-fire or potentially exposed to DU while in close proximity to,or entering previously neutralized targets. Concerns have also been raised by civilian populationsthat have occupied or utilized former battlefield areas potentially contaminated by DU.

Individuals can be exposed to DU in the same ways as to natural uranium, i.e. throughinhalation, ingestion, or dermal exposure. The relative contribution from each of those pathwaysto the total DU-uptake is a function of the physical and chemical character of DU, as well as thelevel and duration or frequency of exposure.

Potentially, DU has both chemical and radiological toxicity with the two important target organsbeing the kidneys and the lungs. Long-term ingestion of uranium, or DU-contaminated drinkingwater, or incidental ingestion or inhalation of DU particles in the soil, may result in damage tothose organs.

The chemical toxicity of natural uranium and DU are identical (ATSDR 1999b). Because theradioactivity of DU is about 60% of natural uranium, its radiologic toxicity is correspondinglyless. The primary radiation types produced by DU are alpha particles, blocked by the skin, andbeta particles, blocked by clothing and footwear (external exposure). Gamma rays are a highlypenetrating energy, but the amount of gamma radiation produced by DU is very low.

However,in the case of internalization of DU, both alpha particles and the corresponding beta particlesfrom the decay products in DU become an issue for health concern.

The available evidence indicates that the highest levels of potential human exposure to DU occurin the battlefield setting. Measurements of DU contamination taken by the United NationsEnvironmental Programe at sites in Kosovo, where DU-bearing munitions were used, indicatecontamination of the ground surface was localized to within a few tens of meters of the impactsite (WHO 2001a). In the extreme case, when "hard" armor-plating, such as a tank, is pierced byDU munitions, the penetration process pulverizes much of the projectile which explodes intoburning fragments when it hits the air on the other side. The result is an airborne aerosol cloud ofDU-oxide particles within the target vehicle. Estimates vary, but perhaps about 10-20% of theDU-projectile mass is aerosolized. These DU-oxide particles formed inside the target arerespirable but with time the oxides adhere to the surrounding metal surfaces or are released tothe atmosphere through openings. The available evidence indicates that in the "worst-case" hard-armor impacts, the DU particles do not vaporize (DOD 2000, Moses 1978).

Follow-up exposure investigations of potential troop exposures to DU conducted after the GulfWar found that the highest levels of potential human exposure to the respirable DU-oxide dustare inside the target vehicle. It was also found that those particles can be re-suspended by re-entry, reclamation, or repair of the vehicle, resulting in a secondary source of potential exposure(DOD 2000).

While respirable DU-oxide dust can be released to the environment, the total volume appears tobe small and localized in close proximity to the target vehicle or point of impact. Conceivably,the very small DU particulate could disperse at greater distances from the source. However,deposition of these fine particles would be widely scattered and, consequently, measurableamounts of DU would not occur in localized areas distant from the source (ATSDR 1997).

Taken together, estimates made of the maximum DU battlefield dose and the ongoing, follow-upmedical evaluations of those individuals subject to the greatest potential exposure to DU-oxideaerosols, do not indicate that Gulf War veterans experience DU intakes high enough to affecttheir health (DOD 2000).

Thus, even on the battlefield, the evidence suggests that the use of DU munitions produceslocalized soil contamination ranging from coarse fragments to very-fine particulate sizes. Anyhealth effects to be attributed to the DU contamination would then be due to the ingestion orinhalation of the DU-particulate matter. Insoluble DU particles, 1-10 m in size, tend to beretained in the lungs, possibly for many years. WHO (2001a) suggests that such a long-termexposure may result in radiation damage to the lungs or possibly even lung cancer if a highenough radiation dose was sustained for a prolonged period.

Like most metals, uptake from dermal exposure is negligible and is not likely to result in adversehealth effects. Even direct contact of DU with the skin for several weeks is unlikely to produceradiation-induced inflammation of the skin. However, with the passage of time, the decayproducts of the DU will result in a higher skin dose and a greater potential health concern.Follow-up studies of veterans with DU fragments embedded in wounds have shown detectableDU in urine, but without apparent health consequences (WHO 2001a). There is no data tosuggest that skin cancer results from dermal contact with uranium or DU dust (ATSDR 1999b,DOD 2001).

The Use and Occurrence of DU at IAAAP

Because of its many unique properties, DU has been used for various purposes during theoperations conducted at the BAECP portion of the IAAAP. The following sections describe theareas where DU was used and a description of that use. Together, this information helps toidentify potential pathways of environmental release of DU.

The occurrence or distribution of DU or other radiologic contamination at IAAAP was evaluatedduring low-level flyovers conducted during October 2002. The draft results of the IAAAP AerialRadiological Survey prepared by the Argonne National Lab (ANL) in conjunction with theRemote Sensing Lab and were released on April 3, 2003 (ANL 2003).

ATSDR reviewed the survey findings presented in that draft report. This document discusses thetechnical aspects of the aerial remote sensing used to discern radiological contamination presentat the IAAAP. For the survey, the entire facility was surveyed as well as a 500-foot wide areaoutside the IAAAP boundary. The survey methods used were similar to other methods used, withmodification since 1958.

Based on this survey, radiation was detected in three areas of the facility. These were the coalpile, Yard E, and Firing Site 12. Through computer enhancement, the radiation detected was thenlimited to man-made radiation (radioactive material enhanced or modified through man-madeactivities). Those sites, in which this type of radiation was detected, were then limited to Yard Eand Firing Site 12 (most likely attributed to the DU). The radiation detected in the coal pile wasfrom the uranium and other radioactive materials normally found in coal.

Yard E is identified as a storage area for licensed DU storage for DU munitions and is not,therefore, a site of release of DU to the environment. Firing Site 12 will be discussed in moredetail later in this document. The aerial survey did not detect any man-made radiation outsidethese areas or outside the confines (public areas) of the plant.

Line 1

On Line 1, from 1947 until about 1962, the first step of the production process was the casting ofbaratols (the spherical-shaped, explosive charge that surrounds the nuclear weapon's core) andthe machining of the casts to ensure a precise fit (TNA 2002; COE 2001). Both baratols and"hydroshot" explosive charges (the small hemispheres of explosives used to test the performanceof the explosives; see the description below in the FS Area discussion) may have contained athin sheet of DU (COE 2001). The machining or grinding of these components may havereleased small quantities of DU to the machining room environment or to any resultant waste. Itis reported (COE 2001) that the waste material from this process was taken to the ExplosivesDisposal Area burn pads for disposal by burning.

Beginning in about 1962, the process of casting the baratols was replaced by a new processwhich involved pressing explosives in a plastic state into molds (TNA 2002). Thus, the need formachining was eliminated and, to the extent that a thin sheet of DU may have been involved inthe baratol at this time, the potential for DU release to the environment from this productionphase was eliminated.

In 1973, the AEC announced that Line 1 would be phased out of operation. In 1975, Line 1operations ceased and were relocated to the AEC Pantex facility, near Amarillo, TX. As part ofthe close-out process, the AEC conducted a radiologic survey of the areas and the buildings itoccupied and determined that no real property contained residual radioactive contaminationabove standards in existence at that time (COE 2001). The Buildings surveyed included: 1-2 thru1-7, *1-11 thru 1 -13, 1-19, 1-40, 1-63 thru 1-67, 1-77*, and 1-137-2 (building numbers in italicsare buildings that were also

surveyed later for DOE [ORNL 2000]).

ORNL (2000) conducted a review of historical records in preparation for performing an indoorradiological survey. The COE (2001) also conducted a records review and interviews of previousBAECP employees to gather information for their Preliminary Assessment. Those investigationsidentified several Line 1 Buildings that may have been, or were, involved with the use or storageof DU or other radiologic materials. In 2000, ORNL detected levels of residual DUcontamination in Buildings 1-11, 1-12, 1-61, and 1-63-6. The DU contamination detected inBuilding 1-61 was restricted to a plastic storage pan (COE 2002).

DU or other radiologic contaminants were not detected in the Line 1 area by the October 2002airborne survey (ANL 2003).

ATSDR concludes that *the evidence available at this time does not indicate that environmentalreleases of DU occurred from BAECP activities conducted at Line 1.*

Firing Site Area

The Firing Site (FS) Area was developed for the testing of explosives and ammunition. TheSouth and North Test Fire Areas, now collectively termed the FS Area, were apparentlyoriginally established to support BAECP operations. In addition to the perimeter fencesurrounding IAAAP to limit unauthorized access to the site, the FS Area is also fenced to furtherrestrict access. There is also a locked gate blocking vehicular traffic to FS-12. Operations at theSouth Firing Site centered around FS-6, and at the North Firing Site Area at FS-12.

FS-6 was constructed in 1948 and this FS is still used for ordnance testing. Quality controltesting of explosives (plane-wave testing) was conducted at this site until these test-shotprocedures were moved to FS-14 in 1972. Apparently, most of the explosives testing at FS-6 didnot contain any radioactive elements, however, some explosives may have contained a thin sheetof DU (COE 2001). This DU would have been pulverized or fragmented upon detonation of theshot. During a walk-over conducted by the COE, DU was discovered in the earthen berm at FS-6. However, the source of this DU is unclear (COE 2001). Little is known of the testing activitiesconducted at FS-14, but information gathered in interviews indicate that testing of small amountsof conventional explosives occurred there (COE 2001).

DU or other radiologic contaminants were not detected in the FS-6 area by the October 2002airborne survey (ANL 2003).

Based upon the available evidence, ATSDR concludes that *the opportunity for human exposureto infrequent and minor environmental releases of DU at FS-6 was extremely limited and doesnot represent a health threat*.

FS-12 was constructed in 1964. Both TNA (2002) and COE (2001) report that during the intervalbetween December 1965 and December 1973, a series of specialized tests called "hydroshots" were conducted exclusively at FS-12. Hydroshots tests were conducted to test the hydrodynamicperformance of the shaped explosives used in the ordnance produced at BAECP.

The explosive device used in the hydroshot testing was assembled in FS-5 and comprised of anexplosive charge shaped as a hemisphere, about half the size of a basketball and weighing from1-3 kg (2.2 to 6.6 lb). The explosive charge was surrounded by a DU ring about 1-2 inches inheight and weighing about 22 kg (48.5 lb). The purpose of the DU ring was to simulate thehydrodynamic conditions in a fully spherical weapon (TNA 2002; COE 2001). A generalizedcross-section of the explosive device is given in Figure 4.

The records indicate that a total of 701 hydroshot tests were performed between 1965 and 1973.These tests reportedly dispersed about 4,000 kg (8,820 lb) of DU that was scattered as far asseveral hundred feet from the FS-12 firing point (TNA 2001). Detonation of the shaped chargepulverized the containing ring of DU, yielding DU-debris ranging in size from coarse fragmentsto very fine particles.

The standing operation procedure was to collect DU fragments after each test and dispose ofthem as radioactive waste. Because fine particles of DU were also produced during the testdetonation, the AEC conducted air monitoring during some of the tests. A concentration ofradioactive material of 5.3E-13 microcuries per milliliter (µCi/ml)[2] was measured at FS-12 (COE2001). Because DU is very dense and will settle to the ground more rapidly than other particulatematerial, the air monitoring did not detect any DU-radioactivity at the IAAAP boundaries.

In 1975 the AEC performed a fairly limited site clean-up at FS-12 by excavating a few inches ofsoil in an area which encompassed the area immediately surrounding the firing site and a "couplehundred square meters" around the periphery of the site. The removed soil was tested anddisposed of as radioactive waste in an offsite facility in Illinois. Although testing results did notfind radioactive contamination at that time, numerous DU fragments have been found recently atFS-12 (COE 2001).

The site was turned over to the Army in 1975 for testing of conventional weapons, not includingDU. Then, in 2000, DU fragments were discovered and the Army discontinued use of the site(TNA 2002). It is theorized that larger fragments of DU penetrated the surface soils a fewinches, shielding them from previous detection or site remediation. Subsequent site maintenance,or the natural process of frost-heave, then exposed the DU fragments now found on the surfaceof the FS-12 site (COE 2001). There is a limited potential for incidental, inhalation exposure toDU for workers involved in munitions testing or site maintenance at FS-12 during the intervalfrom 1975 until 2000. Because DU fragments are so dense, the potential for re-suspension ofthose fragments or particles is low. Therefore, the potential for incidental, inhalation exposureduring the 1975-2000 interval is limited.

As previously noted, DU was detected at FS-12 by the October 2002 airborne survey (ANL2003).

Based upon the available evidence, ATSDR concludes that *during the 1965-1975 interval, therewas a limited opportunity for incidental, inhalation exposure to DU-bearing dust in closeproximity to FS-12 immediately following the detonation of a hydroshot*. The observation bunkerat the site would have helped to minimize employee inhalation exposure to DU fragments andparticles released during detonation of the explosive charge. Because DU particles are verydense, airborne particles would quickly settle to the ground in the nearby area. *Subsequent siteclean-up activities may have re-suspended some DU particles and some incidental, inhalationexposure may have occurred. Also, there is a limited potential for incidental, inhalationexposure to DU for workers involved in munitions testing or site maintenance at FS-12 duringthe interval from 1975 until 2000.*

The conditions created by the detonation of a hydroshot are far less severe than those created bythe penetration of hard armor by a DU penetrator. Thus, it is likely that little if any DU-oxideaerosols were created during the detonation of a hydroshot. Additionally, surface soildisturbance during remediation activities or subsequent maintenance operations conducted at FS-12 had, and have, the potential to result in incidental inhalation exposure. However, ATSDRdoes not know if standard precautions were in place to minimize such potential exposures in thepast. ATSDR recommends that, *if future investigations indicate that soil removal or surfacedisturbing activities must be*

undertaken in this area, care should be taken to minimize thegeneration of dust and the potential re-suspension of respirable particulate.

Because drinking water was drawn from Mathes Lake prior to 1977, there is a slight potentialthat the drinking water supply may have been contaminated with DU. No data is available toevaluate the potential for past groundwater contamination, therefore, *ATSDR also recommendsthat groundwater sampling be conducted, down-gradient to the FS area, to determine if any DU-related, radiologic contamination exists in the shallow groundwater.*

ATSDR concludes that the available evidence indicates that *the localized environmental releaseof DU-bearing dust during hydroshot testing or subsequent remediation activities at FS-12 hasnot resulted in any exposure to nearby communities or residents, including the former residentsof the on-post residential area especially considering the distance from the firing site area toresidential areas on and off the facility.*

The Explosive Disposal Area (EDA) - East and West Burn Pads

The East and West Burn Pads are located within the EDA. They are located in the northeastcorner of IAAAP, approximately one mile from the installation boundary.

The East Burn Pads covered an area of about three acres and consisted of eight raised-earth pads.Each pad was enclosed on three sides to minimize lateral migration of wastes and the complexwas enclosed within a 12-acre fenced area. Operated by BAECP until 1975 and by the Armyuntil 1982, the pads were used for open burning or flashing of explosives-contaminated metal,including DU, to remove the explosive residue (COE 2001). The site was remediated inapproximately 1998 by soil removal. The excavated soil was placed in landfill cells at the InertDisposal Area (IDA).

The West Burn Pads, located near the eastern pads, consisted of two pads measuring about 50feet by 15 feet. Those pads were operated by BAECP, and subsequently by the Army, from 1949to 1982. These pads were also used to flash explosives-contaminated metals. ATSDR has notbeen able to determine if explosives-contaminated DU wastes were flashed at this site. Thewastes generated at this site, from 1950 to 1975, were deposited in the West Burn Pad Landfillalso located within the IDA (COE 2001).

A standing operation procedure for waste from Line 1 activities (AEC, No. 41, Rev. 2, April1971) cited by the COE (2001) states that for wastes involving DU, the burned ash containingexcessive alpha contamination was collected in plastic bags and shipped to Pantex for burial.Although not documented, ATSDR assumes that this order covers the waste generated at boththe East and West pads and that, because the cited order is apparently a revision of a previousorder, similar provisions were made for the collection and disposal of wastes prior to 1971.

Site remediation activities, consisting of the removal of about 12,000 cubic yards of soil from theEast Burn Pad area, were completed in 1998 (COE 2001). Those soils were placed in the IAAAPIDA. The West Burn Pad area was remediated by soil removal in 2000 and the soil was alsoplaced in the IDA (COE 2001). The soils from the West Burn Pad area were subjected to grossradiological screening and no radioactive material was discovered.

The research reports summarized by DOD (2000) include several important conclusions whichare useful to ATSDR's evaluation of whether potential pathways of exposure were created byactivities conducted at the East and West Burn Pads.

First, when flashing explosives-contaminated metal, the burn consumes little oxygen because

theexplosive supplies its own. Explosives, by design, burn very rapidly and, thus, the duration of theburns are quite short unless other combustible compounds are present. Although no data areavailable on the temperatures of the Burn Pad fires, because DU requires a burn temperature of3000° C and because the combustion is so rapid, we conclude that little, if any, of the DU wasoxidized. In the absence of violent explosions, few particles are created that can be caught up inthe smoke and thermal currents generated by the fire.

It is unknown if fine particles of DU resulting from machining or sanding processes conducted atLine 1 may have been transported to the Burn Pads for flashing. Because DU particles are verydense, any particles that could become airborne would quickly settle to the ground in the nearbyarea.

Finally, the extreme conditions cited above that are known to result in the production of DU-oxide aerosols, are absent and it is not likely that DU-oxide aerosols were generated at the BurnPads. For these reasons, ATSDR concludes that *the flashing of explosives-contaminated DU atthe East and perhaps the West Burn Pads did not create an air pathway of DU exposure tonearby communities or residents, including the former residents of the on-post residential area.*

It is unlikely that information can be developed that might permit ATSDR to fully evaluate thepotential for incidental, inhalation exposure of the personnel that conducted the burns at the padsites or for those workers that conducted periodic site clean-up of those burn pads. However,given the information developed about exposure to DU in the military setting, it is unlikely thatadverse human health effects would arise from those potential, incidental exposures.

DU is minimally transferred from soil to vegetation. The uranium bioaccumulation coefficientfactor (CF) for the transfer from soil to vegetation ranges from 0.01 to 0.0001(http:www2.nau.ed; see also Baes et al. 1984). The range in the CF values is affected by the soilacidity: greater uptake with increasing levels of acidity. Plant species also vary in theirbioaccumulation of metals or other substances from the soils surrounding their roots. Given thevery low CF values for uranium and, therefore, for DU, ATSDR concludes that *any DUcontamination of nearby vegetation in the Burn Pads area would have been very minimal and any subsequent burning of the vegetation would not contribute to airborne DU.*

The DU oxides that are formed during a fire have very low solubility, but in time some smallfraction may be leached and potentially migrate to groundwater. The degree of potentialcontamination of groundwater is, of course, influenced by the total quantity of DU oxides left inthe surface soil, the length of time the oxides reside in the surface soils, the depth togroundwater, and other environmental factors.

At this time, information is not available that would permit an evaluation if there was anenvironmental release of DU to groundwater from activities conducted at the burn pads. For thisreason, *ATSDR recommends that groundwater monitoring be conducted downgradient of theEast and West Burn Pad areas of the EDA for evidence of DU contamination resulting from the burning of explosives-contaminated DU at these sites.*

COMMUNITY CONCERNS

Some family members of former BAECP employees and some health professionals haveexpressed a concern that worker's families could have been exposed to Be dust. This potentialroute of off-site migration of Be dust is evaluated below.

Concern:

Were family members or acquaintances of former BAECP employees exposed to Be-contaminated dust brought home on the worker's clothing?

Conclusion:

- Based upon the available evidence, changing and showering facilities were availableand procedures were in place to minimize or eliminate the potential off-site migrationof Be dust. ATSDR concludes that the workers' street clothing, worn home after theirwork shift, was not a potential source of exposure of family members oracquaintances to Be dust.

Discussion:

The existence of change houses is documented in the Preliminary Assessment prepared by DOD(2001). A total of three change houses were used at BAECP. The first change house in use wasapparently in building 1-137-2. In the 1950's, when the capacity of BAECP was expanded totwo production lines, two additional change houses (1-137-1 and 1-137-4) were utilized.Although the available documentation does not specify when change house 1-137-2 was firstutilized, it was apparently used prior to the plant expansion in the 1950's and may have beenutilized from the start-up of production in 1947.

Change house 1-137-2 served personnel in building 1-07. Change house 1-137-1 served workersin buildings 1-10, 1-12, and 1-13; and 1-137-4 served workers in buildings 1-05-1, 1-05-2, 1-100, 1-40, and 1-61. Those change houses were equipped with showers and were located nearthe parking lots and the cafeterias. Their locations would have facilitated and encouraged goodpersonal hygiene and changing at the end of the work shift.

In order to determine how the change houses were utilized at BAECP, ATSDR contactedpersonnel at the Pantex facility located near Amarillo, Texas (when Line 1 operation ceased in1975, those operations were transferred to the Pantex plant). John Campbell of the Pantex plantreported that BAECP workers changed into overalls for their work shift and then removed theiroveralls and showered prior to changing into personal clothing and departing the Line(Campbell, personal communication, 2003). Some security guards have noted that theiruniforms required dry cleaning, and that they did not change clothes before and after their shifts.

An example of the current health and safety guidance for workers in occupations that involveexposure or potential exposure to Be dust is given in the Defense Programs Beryllium GoodPractices Guide (LLNL 1997). That guidance specifies different levels of protection for workersdepending upon the potential level of exposure to Be dust, but consistently requires the use ofprotective overalls in the work areas. The guidance also requires the use of showering facilitiesprior to changing into street clothing. This guidance, although more detailed, is similar to whatATSDR has learned about the use of the change houses and showering facilities at BAECP.

It is unknown at this time what provisions were made for laundering the overalls. Potentially,incidental inhalation exposure to Be dust could occur during the laundering process. Thispotential exposure may represent an occupational exposure but is not an environmental release.

ATSDR concludes that *the workers' street clothing, worn home after their work shift, was not a potential source of exposure of family members or acquaintances to Be dust.*

CONCLUSIONS

In addition to the conclusions listed previously in the Be and DU sections of this public healthconsultation, ATSDR has formulated the following overall conclusions regarding the potentialenvironmental releases and human exposure to Be and DU at IAAAP, the BAECP, and thesurrounding area:

- The information available at this time indicates that there have been no*environmental releases* of either Be or DU from activities conducted at IAAAP or theBAECP that were at levels that would result in adverse human health effects toresidents of the facility or those living outside the facility boundary. Therefore,ATSDR places IAAAP in the No Apparent Public Health Hazard category. NoApparent Public Health Hazard is a category used in ATSDR's public healthassessments and consultations for sites where human exposure to contaminated mediamight be occurring, might have occurred in the past, or might occur in the future, butwhere the exposure is not expected to cause any harmful health effects.
- ATSDR will continue to review the results of current and proposed environmentalinvestigations and, if the findings of those investigations indicate that there have beenor are pathways of human exposure to contaminants at levels of potential healthconcern, ATSDR will evaluate the new data and information and release its findings.
- Prior to 1977, the drinking water for IAAAP came from Mathes Lake. After 1977,drinking water was supplied by the City of Burlington, Iowa Municipal Water Works. No data is available to indicate whether or not DU-related, radiologic contaminationexists in the shallow groundwater.
- ATSDR will attempt to obtain written documentation of the changing and showeringrequirements used at BAECP and any other related information that would permitfurther evaluation of this potential source of exposure.

RECOMMENDATIONS

- ATSDR recommends that the future investigations conducted by the COE- FUSRAPinclude groundwater monitoring downgradient of the East and West Burn Pad areasof the EDA for evidence of DU contamination resulting from the burning ofexplosives-contaminated DU at these sites.
- ATSDR also recommends that groundwater sampling be conducted, down-gradient tothe FS area, to determine if any DU-related, radiologic contamination exists in theshallow groundwater.
- ATSDR recommends that, if future investigations indicate that soil removal activitiesmust be undertaken in areas of DU contamination, care should be taken to minimizethe generation of dust and the potential re-suspension of respirable DU particulate.

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ACRONYMS AND ABBREVIATIONS

AEC	Atomic Energy Commission
ANL	Argonne National Lab
ATSDR	Agency for Toxic Substances and Disease Registry
BAECP	Burlington Atomic Energy Commission Plant
Be	beryllium
CF	bioaccumulation coefficient factor
COE	U.S. Army Corps of Engineers
DOD	Department of Defense
DOE	Department of Energy
DU	depleted uranium
EDA	Explosive Disposal Area
ERC	Emergency Response Command Post
FS	Firing Site
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft.	foot
IDA	Inert Disposal Area
IAAAP	Iowa Army Ammunition Plant
lb	pound
mg/kg	milligrams/kilogram
µCi/cc	microcuries per cubic centimeter
µCi/ml	microcuries per milliliter
µg	microgram
µg/kg/day	micrograms per kilogram per day
µm	micrometer
MRL	Minimal Risk Level
NPL	National Priorities List
NRC	Nuclear regulatory Commission

ORNL	Oak Ridge National Laboratory
PHA	Public Health Assessment
RI	Remedial Investigation
SECOM	Security Command Center
TNA	TN & Associates
U	uranium
WHO	World Health Organization

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FIGURES

Figure 1. Geographic Location of Iowa Army Ammunition Plant-Middletown, Iowa.

Figure 2. Facility Locations, Iowa Army Ammunition Plant

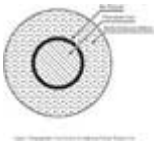

Figure 3. Diagrammatic Cross-Section of a Spherical Nuclear Weapon Core.

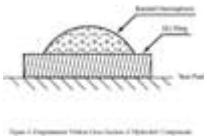

Figure 4. Diagrammatic Vertical Cross-Section of 'Hydroshot' Components.

TABLES

Table 1.

Beryllium contamination detected by wipe samples (1970-1974) - Line 1 Buildings (1,2)

Buildings	Uses at Location	Range of Concentrations Detected (µg/100cm²) -1974 (3)	Highest pre-1974 Detection (µg/100cm²) - NA- Not Applicable (4)	Comments - Date &/or location of sample
Line 1 Cafeteria	Cafeteria		0.0035 - 0.065	04/73
1-11	Receiving & storage	0.00008 - 0.425	>1000 16.0	"Urethane foam, Bay M" "Green Room" - 07/71
1-18	Unknown	0.0003 - 0.0035	NA	
1-19-1 thru -7	Unknown	0.0008 - 0.0420	NA	
1-61-1	"Major caliber loading plant" & "Assembly and shipping"	0.00001 - 0.23543	11.9	"Bay K" - 07/71
1-63-1 thru -7	Component assembly	0.00054 - 0.1963	>1000 6.0	Wipe of Be part - 01/71 Bldg.-63-5 - 09/71
1-64-2&5	Unknown	0.0029 - 0.0165	NA	
1-66-1&2	Unknown	0.0031 - 0.0125	NA	
1-67-3	Unknown	0.00140 - 0.00242	NA	
1-69-1	Unknown	0.0035	NA	
1-77	Unknown	0.0023 - 0.0043	NA	
1-80	Unknown	0.0024 - 0.0036	NA	

NOTES:

1) **These data are presented only as an indication of the Line 1 Buildings that may have resulted in the accidental release(s) of Be to the environment.**

2) Wipe or swipe samples **cannot** be used as a reliable measure of human exposure. They indicate the presence of the substance but the weight/area measurements can be a function of a variety of variables such as the proximity to the source, the time-interval represented by the sample, or the nature or orientation of the surface sampled.

3) The 1974 samples were collected roughly on a monthly schedule by the Burlington AEC Plant Development Department. **The reported "Allowable Limit" was 2.5 µg/100cm².**

4) The available records indicate that the pre-1974 Be sampling was less frequent overall and did not sample the same locations with the same regularity as the 1974 sampling program.

Table 2.

Locations of Beryllium concentrations detected in surface soils at levels greater that the maximum background level (1).

Sample Number	Location	Be concentration (mg/kg)	Investigation
R01-SS-66-01	Line 1 - near sw corner of Bldg. 1-15	1.77	JAYCOR (1996)
RO1-SS-58-01	Line 1 - near east side of Bldg. 1-14	1.89	JAYCOR (1996)
RO1-SS-18-01	Line 1 - west of Bldg. 1-02	1.8	JAYCOR (1996)
RO1-SS-168-01	Line 1 - nw of Bldg. 1-99-5	3.15	JAYCOR (1996)
SU03-SS-0101	Line 1 - outfall near nw corner of Bldg. 1-08-01	3.01	JAYCOR (1996)
10DD25	Line 1 - drainage ditch east of Bldg. 50	1.91	TNA (2002)
30SA-0201	96-feet west of FS-12 pad	2.36	JAYCOR (1996)

Notes:

(1)The surface soil background level for Be is 1.72 mg/kg

APPENDIX A: RESPONSE TO PUBLIC COMMENT

The Agency for Toxic Substances and Disease Registry (ATSDR) circulated the Health Consultation - EnvironmentalPathway Evaluation for Beryllium and Depleted Uranium, Iowa Army Ammunition Plant from August 15 to October 3,2003. ATSDR received two sets of comments during the public comment period. ATSDR's reply to those commentscan be found below.

For statements that question the validity of the statements made in the Consultation, ATSDR verified or corrected thedocument. The list of comments does not include editorial comments such as word spelling or sentence syntax.

1. **Comment:** *The Iowa AAP was placed on the NPL in August of 1990 versus July 1989.*
   Response: The commenter is correct and the text was changed accordingly.
2. **Comment:** *The information that IAAAP received its drinking water from wells after 1977 is incorrect. IAAAP received its drinking water from the City of Burlington, Iowa Municipal*

waterworks. Burlington draws its water from the Mississippi River.
Response: The commenter is correct and the text was changed in three locations.

3. **Comment:** *Health Advisory (sic) Conclusion: There has been no release of Be to the environment at IAAP.*
One of the concerns addressed by the health evaluation was whether or not beryllium (Be) was released by industrial operations at BAECP or elsewhere at IAAAP. The above stated conclusion fails to consider well documented activities at the plant that released significant quantities of Be. As the health advisory correctly points out, beryllium was a component in the nuclear weapon. Since the late 1940s, the AEC and DOE have used hydrodynamic tests to assess the behavior of the nuclear weapons' primaries during an implosion. Hydrodynamic tests were performed using all the same non-fissile components, including Be, and in the same geometries as full weapons. The fissile material was replaced with another non-fissile material (e.g. depleted uranium). Hydrodynamics testing has been carried out more recently at LANL and LLNL. It is likely that the primaries tested in the early stages of hydrodynamics testing at IAAP required greater masses than those tested at either LANL or LLNL. Nonetheless, recent experiences at these other sites may provide insights into exposures at the IAAAP.

At the National laboratories mentioned above, Be is often detected in soils within 75 meters of the hydrodynamics firing site at levels exceeding the EPA action level. Results from soil samples collected at IAAAP, after extensive remediation, revealed several Be soil concentrations in the vicinity of the firing site which exceeded "background" levels and in fact exceeded 4 to 5 fold the referenced average national soil Be concentration. The Health Advisory does not present any information on the Be concentrations in the soils removed from FS-12, which may have had higher Be concentrations and be more reflective of historic risk related to Be. It is not clear that the test area soil concentrations were indeed representative of Be soil concentrations at the time of hydrodynamic testing over 30 years. Assuming the relative percentage of materials released during hydrodynamics testing at LANL's PHERMEX firing site over a 32 year period is similar to hydrodynamics testing at IAAAP, crude total releases for IAAAP hydrodynamic testing would yield environmental deposition of 120 pounds of beryllium, 180 pounds of lead, and 16 Ci of tritium.

Response: The commenter did not accurately quote the conclusion given by ATSDR in the Public Comment release of the Health Consultation. Specifically ATSDR stated; "Based upon available evidence, there has been no release of Be to the environment at IAAAP. The background levels of naturally occurring Be found in surface soils are not of health concern." (see p. 5 above; emphasis supplied)

The commenter asserts that the conclusion given in the Health Consultation fails to consider well-documented activities that released significant quantities of Be. However, the Consultation includes a discussion of the various activities conducted at the Burlington Atomic Energy Commission Plant (BAECP) and evaluates the available evidence of potential environmental releases of Be. ATSDR recognized and discussed that JAYCOR (1996) investigated contaminants in surface soils near Line 1. That investigation found a total of only six detections of Be in excess of the local background level. Of those six detections, Be was only detected once at 2.36 mg/kg in the FS area at a level greater than the background level (see Table 2).

From the findings of the JAYCOR investigations, decisions were made to undertake site remediation activities including soil removal in areas of soil contamination greater than

remediation goals. Thus, when the TNA (2002) collected surface soil samples, only one sample contained Be at a level greater than the local background. As stated in the consultation, those surface soil samples taken together do not indicate an environmental pathway of human exposure to Be in the Line 1 area.

The commenter asserts that Be was used in the "hydroshots" conducted in the Firing Site area. There is no documentation that indicates that Be ever was a component of the explosive devise detonated in the BAECP hydroshot testing program. Rather, the available documentation (COE 2001; TNA 2002) describes the use of a containing ring of DU, not Be, in the testing of the hemisphere of bartol explosive (see Fig. 4, p. 29).

The commenter refers to "several" Be detections in the vicinity of the Firing Site that exceeded background levels and, in fact, exceeded 4 to 5 fold the references for national soil Be concentration. The Consultation (p. 7) discussed the sampling and evaluation previously undertaken by JAYCOR (1996) to establish a local background value for Be in undisturbed, native soils. That local background level was determined to be 1.72 mg/kg. As cited in the Consultation, the national average soil Be is 0.63 mg/kg. Upon closer examination of the data given in Shaklette and Boergen (1984), Be concentrations in the range of 2 to 7 mg/kg have been detected in eastern Iowa even though the mean Be value for the eastern United states is somewhat lower at 0.55 mg/kg. Thus, the local background value determined for Be is well within the regional variability of that element in surface soils.

As previously stated, the surface soil sampling for Be conducted by JAYCOR (1996) detected Be only once in the FS area at a level above the background level. That detection at 2.36 mg/kg (roughly 4 times greater than the national average Be value) results in an estimated oral dose well below the levels of Be known to result in adverse health effects. In fact, the highest detected level of Be near Line 1 (3.15 mg/kg; five times the national average) is also well below the levels that result in adverse health effects.

In the discussion of DU included in the Consultation (p. 14-15), it is noted that there was, "a fairly limited site clean-up at FS-12 by excavating a few inches of soil in an area which encompassed the area immediately surrounding the firing site and a "couple hundred square meters" around the periphery of the site (emphasis added)." Beyond that limited remediation conducted by AEC in 1975, the only other site clean-up activities conducted in this area consisted of collecting the coarse fragments of DU shrapnel that surrounded FS-12 after a hydroshot test was conducted. Thus, ATSDR concludes that the soil sampling by JAYCOR (1996) is representative of the Be content in surface soils in the Firing Site area.

ATSDR contacted the environmental staff of IAAAP and enquired if there were data for surface soil samples collected in the Firing Site area in addition to those reviewed and referenced in this Consultation. ATSDR received confirmation that all the analytical data available for Be detections at the former BAECP and IAAAP was considered in this Health Consultation.

If the commenter is in possession of additional Be analytic data that was not considered in this Consultation and is willing to forward that data to ATSDR, we will review that data to ascertain if it would result in the modification of any of the public health determinations made in this consultation.

4. **Comment:** *Health Advisory (sic) Conclusion: The localized environmental release of DU-containing dust and fragments during hydroshot testing have not resulted in ANY exposure to the nearby communities or residents, including the former residents of the*

on-post residential area.
It is not clear that this statement is valid. First, there is no information in the COE reference to document the accuracy or the representativeness of the air sampling performed at the site. Secondly, approximately 10 percent of the total DU is released as a respirable aerosol that can be transported over 1000 meters from test site. Basically, the same concerns regarding historic risk estimates based upon post remediation soil residues applies to this issue as well. Finally, battlefield exposures may not be representative of the potential for inhalation of DU from hydrodynamic activities.

Response:

The commenter is correct that there is no quality assurance, quality control, or sampling plan information available with which to evaluate whether that air monitoring data given was either accurate or "representative." That air monitoring data is, unfortunately, the only known historical air-monitoring data available and deserves consideration on that basis alone.

The second point made by the commenter is that approximately 10 % of the DU is released as a respirable aerosol that can be transported over 1000 meters from the site. On pages 9 -12 of the Consultation, the potential health effects from human exposure to DU are presented. In that discussion it is noted that a DU aerosol is generated when a DU projectile impacts and penetrates "hard' armor-plating. During the process of penetrating the armor, the DU is pulverized and erupts on the other side of the armor-plate as a burning mass when it hits the air on the other side. In that circumstance, it is reported that perhaps 10 - 20 % of the DU projectile mass is converted to a DU-oxide aerosol which then adheres to nearby metal surfaces but can be released to the atmosphere. However, ATSDR is not aware of any research that establishes that the detonation of a hydroshot results in the heat energy and the degree of pulverization equal to that resulting from a DU-projectile impact on "hard" armor. If the commenter possesses such research information and is willing to share or reference that research, ATSDR will review that information and data to ascertain if any of the conclusions given in the consultation should be revised.

Finally, the commenter questions whether the applicability of battlefield-derived information on DU and its health effects given in the consultation are representative of the potential for inhalation of DU from hydrodynamic activities. The conditions evaluated in the numerous battlefield-related investigations of DU (see WHO 2001a, WHO 2001b, and DOD 2000) are probably not representative of the health hazard possibly posed by the detonation of hydroshots. The battlefield studies represent circumstances far in excess of those relating to the detonation of hydroshots at FS-12. Even in the DU-exposure scenarios evaluated in battlefield-related studies, the research does not point to DU intakes high enough to result in health effects.

It should be noted that even if the hydroshot test conducted at FS-12 did result in the production of a DU-oxide aerosol equal to 10 % of the DU mass used in the test, the prevailing winds at the former BAECP blow towards the east to southeast. Thus, given the location of FS-12 in the western portion of the IAAAP, any DU-oxide aerosols that might be created from the detonation of a hydroshot would be carried to the interior of the installation. The closest IAAAP boundary to the Firing Site area is the boundary directly west of that area. That installation boundary is about 4000 feet (over 1200 meters) away. Thus, even if the wind was blowing towards the west the day of a hydroshot and if DU aerosols were created, considerable dispersion of those aerosols would have occurred. Given the transportation distance and resultant atmospheric dispersion, it is highly likely that any DU aerosols that

may have been created would have been diluted to levels below levels of potential health concern by the time the winds reached the installation boundary.

In consideration of all the factors discussed above, ATSDR concludes that it is very unlikely that the nearby communities or residents, including the former residents of the on-post residences, were exposed to any DU-oxide aerosols.

5. **Comment:** *Health Advisory (sic) Conclusion: ATSDR concludes that workers' street clothing was not a source of exposure of family members or acquaintances to Be dust. Interviews with IAAAP workers suggest that workers did not always change clothes or shower prior to returning home. The results of questionnaire surveys from over 600 former Department of Energy contract workers indicate that in fact 43% of workers reported wearing or otherwise bringing the clothes worn at the workplace home. In the case of some employees such as guards, no provisions were made for changing clothes prior to returning home.*

   Response: The commenter did not accurately quote the conclusion given by ATSDR in the Public Comment release of the Health Consultation. Specifically ATSDR stated; "Based upon the available evidence, changing and showering facilities were available and procedures were in place to minimize or eliminate the potential off-site migration of Be dust. ATSDR concludes that the workers' street clothing, worn home after their work shift, was not a potential source of exposure of family members or acquaintances to Be dust." (see p.18 above; emphasis added).

   It is important to recognize that ATSDR is not empowered to investigate occupational exposures to contaminants; only releases of contaminants to the environment. The available environmental documentation included in the consultation noted the availability and location of the change houses. The information gathered from Pantex plant personnel indicated that requirements were in-place at BAECP to require workers to change into overalls for their work shift and to shower and change into their personal clothing prior to going home. The comment offered above indicates that all workers at BAECP did not follow the change room requirements or, perhaps, some groups of employees were not identified as potentially subject to any occupational exposure.

   Unfortunately, ATSDR has no way to quantify these past exposures. The ongoing investigations into worker exposure to Be at BAECP appear better situated to further evaluate this potential source of occupational exposure.

   Finally, it is important to note that the US Army Corps of Engineers, Formerly Utilized Sites Remedial Action Program (FUSRAP) has an active, ongoing program to gather additional information about environmental contamination resulting from activities at the former Burlington Atomic Energy Commission Plant. It is important that interested community members communicate their concerns to FUSRAP to ensure that they are considered in the development of site investigation and sampling plans.

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[1] - Staballoy is also known as depletalloy and as D-38.
[2] - The units microcuries per milliliter (μCi/ml) are reported in (COE 2002) but the typical concentration units for air are microcuries per cubic centimeter (μCi/cc). These two units are equal to one another.

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