NEEDS ASSESSMENT-DECEMBER 2001

Burlington Atomic Energy Commission Plant—
Former Worker Program

A US DOE funded project conducted by:

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1. INTRODUCTION

In August of 2000, the University of Iowa College of Public Health initiated a needs assessment study to evaluate whether or not individuals formerly employed by the Department of Energy (DOE) at the Iowa Army Ammunition Plant (IAAP) near Burlington, Iowa, would benefit from a Former Worker Medical Surveillance Program. These workers were employed at IAAP in the atomic weapons industry on what was known at the facility as Line 1 or Division B at the Burlington Atomic Energy Commission Plant (BAECP). IAAP is located in Middletown, 10 miles west of Burlington, Iowa.

The Line 1 operations consisted primarily of atomic weapons assembly and disassembly and were functional from 1947 through 1975. These activities involved assembling and/or modifying and disassembling components manufactured at other Atomic Energy Commission (AEC) facilities, as well as manufacturing and processing large quantities of "conventional" or nitrogen-based high explosives. This site is somewhat unique among DOE sites in that the facility was historically shared with the Department of Defense (DOD). The DOD produced conventional weapons at the same time that AEC contractor manufactured, modified, or disassembled atomic weapons. The IAAP facility is still functioning as an ammunitions manufacturing plant; however, all DOE activities ceased and were transferred to the Pantex plant in Amarillo, Texas in 1975.

The goal of the needs assessment was to determine the type and degree of detrimental exposure to hazardous substances, define the health impacts, determine the size of the former worker target population, and clearly document the need for establishing a medical surveillance program for former AEC workers at IAAP.

The specific accomplishments of the first year of the needs assessment include:

1. Developed a working relationship between the project team and local unions, IAAP site management, community representatives, state and local public health officials, and medical providers. A Community Advisory Board with representation from the above stakeholders was convened in November 2000.

2. Conducted significant media outreach through two public meetings, and press releases sent to more than fifty newspapers in southeast Iowa and areas of Illinois and Missouri within driving distance of Burlington.

3. Identified health concerns of the work force through public meetings, pilot surveys, focus group interviews, fully-staffed project phone lines for workers or relatives to call in, and a collection of oral histories compiled by the Burlington Hawkeye, the local newspaper.

4. Located, reviewed, and coded existing data sources to identify the greater cohort employed at IAAP, and narrowing the cohort to those who worked in the AEC sectors of the facility between 1947 and 1975. Data sources include paper copies of employment records, union seniority lists, lists generated by former workers, and focus group interviews.

5. Generated an electronic registry of past employees during the relevant time period, and categorizing them to the extent possible as having been employed by the AEC, the DOD, or both. Categorization is based on job codes, self-reported anecdotal information, and focus group interviews.

6. Identified, collated, and reviewed existing sources of radiation, industrial hygiene, process, and waste stream data regarding potential exposure to occupational hazards related to AEC activities.

7. Determined the most significant occupational health risks and health concerns of the work force through literature and records review, risk assessment and mapping, and focus group interviews.

2. METHODOLOGY

A number of methods were employed during this 12-month needs assessment period including personal interviews, review of historical industrial hygiene, process, personnel, medical, environmental monitoring and safety records.

A. Community Advisory Board

The University of Iowa project established a Community Advisory Board (CAB), which held its first meeting November 9, 2000. Public attendance and interest at the CAB meeting indicated the need for much larger informational sessions that were open to the public. Two additional public meetings were held in January 2001. The January 10 meeting attracted nearly 175 members of the public, and 300 people attended the January 24 meeting. A fourth meeting served as a working session for invited participants to refine and screen personnel, process, and industrial hygiene information. We hope to have clarified the focus and scope of the BAECP former workers' project through these public meetings and through our availability to the local media, advertisements and press releases. These public meetings have provided an opportunity to recognize and address questions or concerns from the community, and have proved to be very helpful in identifying former workers. Community interest and participation appears to be very high in the Burlington area.

B. Cohort Identification

As of March 20, 2001, data entry of IAAP employment records was finished. Identifying information from 3 x 5 note cards stored at IAAP was entered into an electronic database for 36,315 workers. The cards listed the worker's first and last name and middle initial, social security number, dates of employment, and job codes. The available data only rarely differentiate between those who worked for Division A (the larger portion of the plant that was run by the US Army/DOD), versus those who worked for Division B/AEC. Interviews with former Line 1 workers yielded a smaller subset of job codes that these workers believe were specific to Line 1, along with codes they were certain did **not** apply to Line 1.

Preliminary identification of 2545 Division B/Line 1 workers has been completed. The initial identification process relied on several sources of information, including: people who called in to identify themselves as Line 1 workers; union seniority lists; names collected from industrial hygiene and radiation dosimetry reports; and specific unique job codes. The breakdown of sources of Line 1 identifier information includes in descending order of frequency:

877	employees whose job codes match those from the IAMAW (Machinists' Union) Division B seniority lists
515	former employees who have called in and identified themselves as Line 1 workers
430	employees for whom we have radiation badge information
404	employees identified from Division B/Line 1 IAMAW seniority lists
350	laborers (identified by the job code L-2 which appears to be a laborer code specific to Division B)
220	guards (most of whom were Q cleared, but we are unable to eliminate those who were not)
146	employees identified from 3 x 5 card data and medical records as Line 1 employees
48	employees listed in industrial hygiene MOCA access/exposure logs from buildings 1-61, 1-40 and 1-12
40	employees whose job codes indicate they worked on the firing sites
18	employees whose job codes indicate administrative or research & development activities
15	press operators, who pressed the high explosive (HE) into its initial form
15	x-ray operators and technicians identified by job code

Eighty-two employees' job codes matched the identified Line 1 codes, but their employment started after 1975, so they were subtracted from the list. This leaves a total (after eliminating duplication) of 2545 employees preliminarily identified as Division B/Line 1 workers.
We continue to receive an average of 5-10 calls per day from former workers or their relatives. As new Division B/Line 1- job codes are identified, the master data base of 3x5 cards will be queried and those names with matching codes will be added to our list of known or assumed BAECP workers if the codes appear to be specific to AEC operations. We continue to collect lists of previously unidentified AEC workers generated by other Line 1 contacts. Since there appears to be no singular list of all "Q" cleared or AEC employees covering the 1945-1975 time frame, further identification and validation of the cohort will continue throughout the course of the survey, with the ultimate goal of identifying all former BAECP workers.

C. Risk Assessment

The UI project team located several maps of the Line 1 area that include building numbers. We developed a preliminary site and process history based on interviews with former workers, archived documents, and tours of Line 1. The site history is revised and updated after each focus group or interview with former workers.

Since August 2000, we have extensively interviewed approximately two-dozen former workers. Among these interviewees were the Division B Health and Safety officer for over 30 years, the current Health and Safety officer at IAAP, the plant's Chief Chemist from the 1950s through the 1970s, and several other production and maintenance supervisors and employees. We are in regular contact with Health and Safety professionals at Pantex.

Mr. Bert Griswold of the Albuquerque DOE office had previously assembled a box of documents that he found pertinent to the Burlington site. We were able to access these documents at IAAP. These documents contained various pieces of information that referenced the AEC cleanup at Burlington in 1975; beryllium swipe data results by location; area noise surveys; reported complaints and follow-up monitoring relative to various chemical exposures; radiation swipe data for products and building locations; annual health and safety survey reports; memoranda, policies, exposure controls and biomonitoring for MOCA, and other miscellaneous references to industrial hygiene and environmental data not included in the box.
Pantex has provided us with a box of records including radiation exposure data for over 400 Line 1 workers. There is reportedly one box of Burlington records sent from Pantex to DOE headquarters pending evaluation and possible declassification. Negotiations have been ongoing with Pantex to access further pertinent records that are reportedly still held on-site. We have also received results of the beryllium tests done by ORISE on 277 former and current IAAP workers and have completed 9follow up evaluations for those who have screened positive on two beryllium LPTs.

PRINCIPAL FINDINGS

A. Primary Exposure Hazards

In the production of weapons, Division B workers were engaged in various assembly and disassembly operations that posed potential exposure to hazardous materials or agents. Operations included melting, pouring and molding, pressing, machining, storing, reclaiming, and burning explosives or their waste products. Workers combined containers of fissionable material with explosives, and assembled uranium packages for further assembly down the production line. Chemical formulation and analyses of assembly compounds and weapons components were performed in the on-site laboratories. Casts made of various metals were tooled and machined, and some components were also sandblasted and painted. Workers used solvents such as methyl ethyl ketone, toluene, and acetone to clean parts and equipment. MOCA, adiprene, and isocyanates were used during melt, assembly, and bonding operations. Heavy metals were used in primers, paints, and plating operations. X-Ray and gamma sources were used for quality assurance.

Some employees were likely exposed to occupational hazards who were not directly involved in production operations. These workers include guards on surveillance duty, laundry personnel who handled contaminated clothing, and various delivery and storage personnel. Contractors and IAAP employees involved in ongoing construction activities throughout the BAECP facility were exposed to high noise levels, paint vapors, asbestos, and silica.

Other AEC-associated areas included the Explosives Disposal Area, firing sites used for high explosives and hydroshots, and storage and refueling yards. The above-mentioned processes and areas are detailed in the risk map table on page 16.

1. Beryllium

Beryllium is classified as a probable human carcinogen. Occupational exposure can lead to a variety of health effects, although beryllium is primarily recognized as a cause of obstructive airways, pneumonitis and progressive granulomatous lung disease. We have concluded that machining, tooling, sanding or grinding of beryllium alloy tools or atomic weaponry components was occasionally performed on both Division B/Line 1 and Division A/DOD operations. It is evident that AEC workers performed light machining (e.g. abrasive sanding) of beryllium alloys during assembly of atomic weaponry. Several workers described on site production of beryllium alloy chisels and scrapers that were used in production, working with beryllium plates that crushed explosives, and "filing" or honing their non-sparking beryllium tools. Industrial hygiene air-sampling data for particulates are referred to in documents reviewed on-site, and have been requested from the Pantex facility.

We have reviewed swipe sample data from a variety of work areas within Line 1 for years 1970 through 1974. These data are incomplete for the periods listed and do not correspond to the entire period that AEC operations were conducted at IAAP. A 1971 summary report indicates swipe samples ranged from 0 to 1000 Πg/m^2. A 1973 swipe sample report noted area concentrations from 0 to4.12 Πg/m^2. A 1974 swipe sample summary noted surface concentrations of 0 to 111.6 Πg/m^2. The allowable reference "limit" for surface contamination from this era was reportedly 2.5 Πg/m^2. These swipe sample data are at best qualitative measures of potential for exposure to beryllium, and indicate work areas where beryllium was a recognized risk, and where air sampling data would be beneficial.

To date, LPT beryllium screening of a small subset of the IAAP workers has revealed that 5 of the 277 participants have twice tested positive for beryllium sensitization using peripheral lymphocyte transformation assays. Evidence suggests that chronic beryllium lung disease can have a long latency period and is not related to duration of exposure. An example: one of the five sensitized workers from IAAP was employed in the laundry facility at the plant for two months in 1968 and had no other potential work history exposure to beryllium, and no direct exposure to AEC processes other than handling workers' clothes. A second of these five workers was employed exclusively on DOD lines from 1959 to 1982, but was married to a Line

1 inspector. Another former DOD worker with beryllium sensitivity and evidence of early pulmonary fibrosis is the spouse of a former Line 1 worker (1960-1987) who was employed as a tool and die worker. He frequently machined and manufactured beryllium alloy tools, and reportedly wore his work clothes home, which were laundered by his wife.

LPT screening results that document prevalence of beryllium sensitization among IAAP plant workers appear to be comparable to several other DOE facilities. Post-cleanup wipe sample data indicating persistent surface beryllium contamination suggests the need for more comprehensive screening of this population. We have recently received and are in the process of reviewing the hard copy results from LPT assays and work histories from the 277 workers who have been screened to date via ORISE. We are in discussions with DOE and ORISE staff regarding the possibility of facilitating further beryllium screenings for this population and have made preliminary arrangements for physical facilities on-site where medical screening might be provided.

2. Radiation

Exposure to radiation was a common concern expressed by former workers with a wide variety of job titles. The topic was brought up at public meetings, during phone calls, and at focus groups. While many of the workers stated they thought their radiation exposures were well monitored, other workers voiced concerns. It is clear that many production workers and others potentially at risk were not monitored. For example, many of the security personnel stated that even though they worked around radioactive materials, they were not provided dosimetry. Several of the security guards who did not receive dosimetry recall receiving and supervising transport of the radioactive materials when they arrived by rail. Other workers without history of monitoring provide accounts of spending their entire shift in the rooms where the devices containing radioactive materials were partially assembled. Personal interviews of production workers also indicate that even if badges were provided, they were not worn by these workers in the bays but were left either in their lockers or on a main storage board.

Based on the Burlington dosimetry records recently received from Pantex, it appears that only about 10 percent (~ 500 individuals) of the former AEC workers were provided personal dosimeters. A former Health and Safety Officer stated that dosimetry was "provided to the workers who had the greatest potential for exposure". However, in the event of an accident or undetected radiation release, it would have been possible for workers without dosimetry to receive non-quantifiable exposures.

Regardless of the validity of the risks based on workers' reports, there were numerous well-documented sources of potential radiation exposures. The records received to date indicate there were a variety of radiation sources at the Burlington plant, including various nuclear weapons component materials, radiographic equipment, depleted uranium, and radon.

a. Radiation Sources

1. Nuclear Weapons Components

   The primary radiation sources at the plant were associated with the nuclear weapons component materials including uranium-238, uranium-235, plutonium, and tritium. Memoranda indicate that approximately 0.006 curies per year of tritium was released to the environment. Safety reports indicate that swipe counting and direct surveys routinely monitored removable and non-removable radioactive contamination. We have not located documentation of any of these surveys to date.

2. Radiographic Equipment

   A 1969 Health Protection Appraisal Report indicated that there were 2-1 MeV, 1-3 KeV, 1-250keV, 1-110 keV generators and a 5 and 50 Ci cobalt-60 source used at the plant for non-destructive testing.

3. Depleted Uranium

   Several recently received safety reports indicate that several pounds of uranium-238 were routinely converted to a fine oxide powder during each hydrodynamic explosive (hydroshot) test routinely performed at Firing Site 12 (FS12). It was estimated that 8,800 pounds of depleted uranium was exploded at FS12 in 701 hydroshots between 1965 and 1973. Firing site employees were responsible for picking up hot shards of depleted uranium from the firing site.

   Several workers at the firing site report that many of the people who worked at the firing sites have developed numerous types of cancer including bladder cancer. Reports suggest that direct surveys were performed at the sites for uranium including air samples and soil samples. Memoranda retrieved from files at the Burlington Plant suggest that approximately 2,000 grams per year of depleted uranium are burned at the disposal field. A 1969 Standard Operating Procedure describes protocols for burning normal or depleted uranium machine turnings intermixed with explosives or mock explosives. Burn pad ash residue containing excessive alpha contamination was to be collected in plastic bags and shipped to Pantex for burial.

4. Radon

   Former Health and Safety Officers at the Burlington Plant stated that many of the buildings, particularly underground structures, have been tested for radon gas. We have been unable to obtain the results of these tests to date. Our Year 2 plans include conducting retrospective radon testing of Line 1 buildings.

b. Exposure Records

We received from Pantex several thousand pages of personal dosimetry and area monitoring reports for the Burlington Plant for the years 1956-1975. The records include reports from either Tracer Labs or Landauer listing exposures to penetrating and non-penetrating radiation. The completeness of data has not been determined at this time. A superficial review of the dosimetry records suggest that the overall exposures generally were within established guidelines, but slightly exceeded the range of exposures reported for the workers at the Nevada Test Site. A quick scan of the data indicates that many of the higher exposed production workers were women. There are some reports by workers that some of the women who worked on the production line worked late into their pregnancies

Overall, the majority of the highest yearly exposures appear to have occurred in the early 1970s. There appears to be limited monitoring of extremities. A few records retrieved from the Burlington plant suggest that a bioassay program was in place during some years for tritium analysis. These records have been requested from the archives held at the Pantex plant. Limited surface swipe data is available for "products" received during production years, and for building surfaces at the time AEC operations were closing and moving to Pantex. These will be reviewed and compared to exposure data by area when possible.

3. High Explosives

One relatively unique aspect of this cohort is the extent of exposure to various high explosives. For much of the workforce there was considerable potential for dermal and airborne exposure to agents through process of formulation, melting, pouring, packing, and extensive machining to manufacture shaped charges. Several former workers described personal or coworker episodes of extensive dermal and hair discoloration resulting from high explosives exposures. Curiously, reviews of the literature suggest this discoloration is as likely to be systemic as a local manifestation.

There has been considerable concern expressed by former workers and their families regarding possible occupational hepatotoxicity and hepatic carcinogenicity related to explosives exposures. A March 11, 1947 Intelligence Check sheet of Burlington plant operations documents one death and the loss of 39 workdays for four other workers due to systemic TNT poisoning. It is not possible to determine whether these were specific to AEC or DOD activities although one would suspect the latter to be more likely. On-site industrial hygiene and medical records received to date contain no exposure or biomonitoring data for explosives or their effects.

a. TNT 2,4,6-Trinitrotoluene

Toxic hepatitis is the principal manifestation of 2,4,6-trinitrotoluene toxicity in humans. US Army studies documented measurable effects on liver functions among workers exposed at or close to the currently accepted TLV. There may be a number of reasons for variability in individual susceptibility to such effects.

A recent case-control study of Chinese workers exposed to TNT indicated that the risk of liver injury is increased among heavy drinkers as compared to workers who are not heavy drinkers. Several studies of Chinese workers have indicated reproductive effects of TNT. Case-control studies in two TNT plants in China of effects on semen revealed significantly lower semen volumes and a smaller percentage of motile spermatozoa, as well as a significantly higher incidence of sperm malformation, in exposed compared to control workers. Controls were matched to exposed workers on income and residence. The presence of mutagenic compounds in the urine indicative of mutagenicity has been noted in several investigations of workers exposed to TNT. Urine samples collected at the conclusion of a work shift were assessed for mutagenic activity using Salmonella typhimurium and Escherichia coli strains. Evidence of mutagenic activity was present in the urine of groups exposed to TNT, but significant genotoxicity was confined to urine from individuals in the high exposure groups.

Lab animal studies have shown elevated rates of leukemia and/or malignant lymphoma of the spleen among rats exposed to TNT. A 1993 study of a German population living in proximity to two World War II era munitions plants indicates an association between increased rates of some types of leukemia and living in a town near TNT waste from these plants. The study revealed increased relative risk of acute myelogenous leukemia for both adult males and females living near the former explosives plants when compared with adults in a neighboring county. The relative risk was particularly high for individuals over 65 years of age. The relative risk for chronic myelogenous leukemia was also elevated for males, but there was only one case among females. It is not clear how many individuals in this population might have been occupationally exposed in these plants. Based on animal studies, EPA has classified TNT as a possible human carcinogen (Group C).

The appearance of cataracts is another observed effect of TNT chronic exposures. Irreversible equatorial lens opacities/cataracts have been reported in both Chinese and Finnish workers exposed to TNT for over five years. As with dermal discoloration, it is unknown whether this is a systemic or local toxicity. The progression of the cataract is observed to stop if the exposure to TNT stops. The mechanism of TNT cataract formation is not understood, but the possibility was raised that free radical formation and/or covalent binding to macromolecules may play a role. Some investigators have used hemoglobin adduct formation and excretion as measures of TNT exposure and bioeffect and as a measure of risk for toxic injury.

b. RDX Cyclonite, Hexahydro-1,3,5-trinitro-1,3,5-triazine

The predominant toxicity reported for workers exposed to RDX by the inhalation or oral routes is neurological with seizures, convulsions, confusion, muscle twitching, hyperirritability, and amnesia. One lab animal study found statistically increased incidences of combined hepatocellular adenomas and carcinomas in female mice. Otherwise, there is little information regarding potential chronic toxicity from RDX.

c. HMX Octahydro-1,3,5,7 tetranitro-1,3,5,7-tetrazocine

Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine is an explosive polynitramine commonly known as HMX (derived from High Melting Explosive, sometimes called “her majesty’s explosive”). Similarly to RDX, HMX toxicity appears to be largely neurological with hyperkinesia, hypokinesia, convulsions, mydriasis, cerebral edema, and/or hemorrhage noted in laboratory animals, and animal studies suggests that HMX may exert hepatotoxicity among highly exposed individuals.

d. Tetryl Tetranitromethylaniline

Human studies of tetryl exposure indicate sub chronic occupational exposure can result in various digestive disorders including loss of appetite, abdominal pain, vomiting, and loss of weight. Tetryl exposure can induce diffuse central nervous system effects such as headaches, insomnia, exaggerated reflexes, mental excitation, malaise and fatigue. Other effects observed after oral tetryl exposure include chronic hepatitis, leucocytosis and a slight anemia. Although there have been no epidemiological studies of hepatic function in exposed workers, there have been several case reports of hepatic toxicity including fatalities among highly exposed workers. Picric acid, a metabolite of tetryl, has been associated with functional and clinical indications of liver impairment (elevated bilirubin and urobilinogen and jaundice) following inhalation or oral exposure in both animal and human exposures. The most common effects observed in workers exposed to tetryl dust (e.g., skin discoloration and dermatitis) were believed to have been caused by dermal exposure to the compound. Workers that handled tetryl in manufacturing plants frequently developed a yellow staining of the hands, face, and hair. Several former IAAP workers and or family members anecdotally recalled cases of "yellow skin," "yellow hair," or "sweating their sheets and clothes to a yellow color." In addition to dermatitis, tetryl has been associated with acute and delayed hypersensitivity reactions. Epidemiological studies revealed that workers exposed to tetryl during the manufacture of explosives occasionally developed irritability, headaches, fatigue, and insomnia.

4. MOCA 4,4'-Methylenebis(2-chlorobenzenamine)

MOCA was introduced in the mid-1950s in the production of high-performance polyurethane molded products and sealants. MOCA was used as a curing agent for adiprene, and was used extensively to bond components, with or without high explosives.

MOCA is classified as probably carcinogenic to humans (Group 2A), based on human case studies and experimental animal data suggesting causal association with bladder cancer. MOCA forms adducts with DNA, both in vitro and in vivo. Animal testing has shown risk for transitional-cell carcinomas of the urinary bladder and urethra in beagles, and lung adenocarcinomas and hepatocellular tumors in rats. MOCA was widely used in epoxy resin processes in the assembly of various components of weapons manufactured at this facility.

We have reviewed copies of correspondence among and between AEC and IAAP contractor management dated on and around 1973 involving control processes to reduce MOCA exposures following OSHA's emergency standard on carcinogens. These controls included installation of laboratory hoods, glove box operations, and negative pressure change rooms; personal protective equipment and clothing; product smear samples and employee access logs; and employee biomonitoring (urinalysis). These process and administrative controls affected employees in several work areas, including buildings 1-12, 1-40, 1-53, 1-61, and 1-63-7. To date, we have not located air sampling data to document airborne exposures.

We have thus far identified 48 employees recognized as being at risk to MOCA, based on employee urinalysis and MOCA access records. Reportedly there are additional relevant industrial hygiene and biomonitoring records available at the Pantex site and we are trying to locate and arrange for the receipt of these records.

5. Asbestos

The IAAP has two coal-fired power plants and miles of asbestos-coated steam pipe coursing the complex as well as many miles of tremolite asbestos fiberboard lined tunnels. Much of this asbestos insulation or construction material is in relative disrepair with visible friable areas upon cursory inspection. Asbestos is classified as a Class A known human carcinogen based on extensive human epidemiology data. The primary target for asbestos is the lung with chronic inhalation resulting in an interstitial fibrotic lung disease termed asbestosis. Asbestos inhalation exposure can result in all cell types of lung cancer as well as mesothelioma (a mesenchymal cancer of pleura or intra-abdomenal connective tissue), and possibly gastrointestinal cancers in humans. Asbestos's risk of lung cancer is well known to be synergistic with risk from tobacco use, hence a recognized need for and potential benefit from secondary prevention in the form of smoking cessation.

Contract workers and maintenance employees at BAECP were involved in constructing and installing miles of asbestos board structures.

Awareness of asbestos hazards and locations is quite prevalent among many BAECP workers, as are their recollections of acquaintances or former coworkers they believe died of lung cancer.

6. Noise

Area noise surveys are available for several Division B/Line 1 locations, including firing sites. Earliest data currently available date to the mid 1960s and reflect noise levels in machine shops, fabrication areas, explosives machining areas, and assembly. Surveyed noise levels exceeded 90 dbA and/or 85 dbC in many production and maintenance areas. Noise data do not appear to have been regularly collected, but may have been in response to complaints or implementation of special processes, such as construction jack hammering, or operating concrete saws. Hearing protection was used in a few areas, but at this point we do not have records or data that show widespread use or policies for hearing protection in general production areas. As mentioned previously in one employee's account of firing site exposures, impact noise was not necessarily regarded as problematic. Our current compilation of area noise exposure data is included in Table 1. We hope to find more information regarding noise exposures in Pantex records. Most noise exposure controls reviewed to date have addressed hearing protection rather than engineering controls.

7. Silica

Silica exposures were not part of weapons production operations at IAAP, but were likely common during construction activities that involved concrete floor sawing and replaning, sand-blasting in preparation for painting, or masonry work. No exposure data has been identified to date specific to silica or respirable dust exposures. However, other industrial hygiene data referencing noise and carbon monoxide exposures during operation of jackhammers indoors, or gas-powered engines for concrete planing or sawing indicate that silica exposures existed. Several production workers have referred to cutting and resurfacing concrete floors for specific activities and uses throughout Line 1.

8. Solvents

Solvents were used extensively during the entire span of AEC production activities at IAAP. Solvents were used to clean component parts upon receiving and during production and assembly operations as well as in paint thinners. Common solvents involved in production included but were not limited to acetone, toluene, alcohols, methyl isobutyl ketone, and xylene. Solvent use was also documented during equipment and floor cleaning operations. We have limited industrial hygiene data regarding solvent exposures during routine production uses. Measured exposures at times exceeded the then-Threshold Limit Values in particular at operations where solvents were heated in kettles (building 1-05) or were used in areas without exhaust hoods. We expect that a large number of production employees may have had some exposure to solvents, since they were so widely used in most stages of component and equipment cleaning. Safety department memos indicate recommendations for use with local exhaust when possible. References to respiratory protection and/or gloves were not noted in documents we have found to date.

Risk Mapping

We gathered "expert" former and current workers in focus groups to obtain in-depth information about the industrial processes and exposures across the plant and the BAECP facility changes over the years. We obtained detailed schematic maps of the facility and are in the process of matching it to lists of processes, products, and exposure data to develop a risk map. A table summarizing location, process, exposure, and timeline data follows. This table is periodically revised as we accumulate new exposure data or review documents that provide information regarding process or building use, safety measures, or personnel information.

B. Nature and Extent of Health Impacts Experienced by Former AEC Workers

Although our results are certainly to be viewed as preliminary, the findings of the needs assessment activities to date clearly support the development of a targeted medical surveillance program. Based upon self-reports and medical records reviews, this cohort of fewer than 4,000 workers has experienced high rates of suspected work-related diseases including Glioblastoma, (four), Other Brain Cancer, (nine),Leukemia, (nineteen), Lymphoma, (twenty-three), Thyroid Cancer, (three), and Bladder Cancers, (nine). The justification for continuing community based activities including implementing medical screenings is based on the suggestive evidence that large numbers of workers had significant exposures to detrimental agents and the strong need expressed by former workers for a credible targeted program of medical surveillance and education. A medical screening/health protection and risk communication program should center on workers at risk for

1) Bladder cancer from MOCA and other aniline derivatives,
2) Chronic Respiratory Disease, including chronic obstructive lung disease resulting from isocyanates or other occupational toxicants
3) Pneumoconioses resulting from occupational exposures to mineral dusts in the form of beryllium, asbestos, possibly plutonium, (unlikely), and/or silica, (also relatively unlikely)
4) Lung cancer, while cigarette smoking will certainly have played a major role, occupational exposures to recognized lung carcinogens such as asbestos, beryllium and possibly radon, (given the underground work environment in a high phosphate geologic zone), need to be considered.
5) Radiation induced cancers, a major concern resulting from our first years' activities is the fact that radiation exposure monitoring for this cohort was clearly incomplete and inconsistent. The majority of the workforce was not monitored at all despite area exposure monitoring indicating potentially clinically or epidemiologically significant exposures.

Some of these conditions are amenable to early intervention (bladder cancer); amelioration (chronic respiratory diseases), and primary prevention (lung cancer via smoking cessation). Risk communication activities delivered by a credible source(s) would reduce uncertainty and distrust and may confer some psychosocial benefits to the former workers, their families and the community in general. As a result of participation in the proposed screening programs, former AEC/DOE workers will have increased information regarding their personal health status, what is known about their risks, and how they can promote their own health. We believe that developing and implementing such a program in Phase II will tangibly improve participants' quality of life in addition to assisting them with the maze of acronyms and paper work involved with the DOE/DOL Workers' Compensation system.

C. Educational Needs and Health Concerns of Former Workers

Focus groups and individual interviews provided considerable insight about how former workers viewed the significance of their prior exposures, and their current state of knowledge, health concerns, and health care.

The following themes arose as a result of these focus group sessions and individual interviews:

- ξ Strong feeling of personal vulnerability to disease as a result of DOE employment
- ξ Overwhelming feeling of uncertainty and ignorance about significance of exposures; whether personal illness was caused by occupational agents; and what actions might be taken to protect one's health
- ξ Sense of shared risk with co-workers, such that co-workers' ill health reinforces one's own risk
- ξ Deep sense of distrust about communications from and actions of DOE contractors

Section 4. Need for Medical Surveillance and Risk Communication

The results of the Phase I risk assessment support the need for a medical monitoring and risk communication program. Risk assessment data will continue to be collected in order to determine:

- ξ Identification and location of former Line 1 workers during the period of interest. Work history questionnaires will also be sent to the remaining 36,315 former workers from 1947-1975 to determine their potential status as Line 1 workers.

- ξ What are the worker concerns regarding exposure to hazards of their AEC jobs

- ξ What communication materials and methods are most effective in addressing these concerns.

- ξ Continue risk characterization through analysis of IAAP and DOE documents, many of which are still going through a declassification process. There is a dearth of historical records, especially for radiation exposure complication retrospective dose estimation.

- ξ Develop algorithm for exposure assessment related to medical surveillance, for example attempting to determine the likelihood of MOCA, Asbestos, Beryllium, Isocyanate, Radiation, High Explosives, Heavy Metals and solvent exposure based on work history, location and process histories.

- ξ Increase community awareness of the program through increased outreach efforts in communities surrounding Burlington, using the guidance of the Community Advisory Committee, Union contacts, and discussion seminars.

- ξ Identify worker perception and concerns, and develop methods to address those concerns.

- Develop upon and continue collaborations with labor and former worker groups including fostering relationships with both past and current union leadership.

- Develop and distribute improved risk communication educational materials through a variety of modalities including one-on-one counseling during clinical screening; press releases, articles and interviews in televised, radio and print media; internet web pages; public forums and direct mailings.

- Implement medical surveillance exams in a cost-effective manner consistent with DOE goals and including screenings and recommended follow-up referrals for occupational diseases not covered by the current legislation.

- Work closely with DOE, the Workers Advocacy Department and the Iowa Division of Workers Compensation in relation to the Federal Compensation Plan in order to evaluate and coordinate claims. There is currently no mechanism for retirees diagnosed with occupational diseases over one yerar after their last injurious exposure to seek compensation through the Iowa State Workers' Compensation system. We are working to educate the community including the Iowa legislature regarding this issue and working closely with the Iowa Workers' Compensation Commissioner Iris J. Post to reconcile this concern.

- Assist with efforts for timely resolution of workers compensation claims as they arise out of the medical screenings.

- Develop a mechanism to evaluate patient satisfaction using surveys.

1. Beryllium

Beryllium is classified as a probable human carcinogen. Occupational exposure can lead to a variety of health effects, although beryllium is primarily recognized as a cause of obstructive airways, pneumonitis and progressive granulomatous lung disease. We have concluded that machining, tooling, sanding or grinding of beryllium alloy tools or atomic weaponry components was occasionally performed on both Division B/Line 1 and Division A/DOD operations. It is evident that AEC workers performed light machining (e.g. abrasive sanding) of beryllium alloys during assembly of atomic weaponry. Several workers described on site production of beryllium alloy chisels and scrapers that were used in production, working with beryllium plates that crushed explosives, and "filing" or honing their non-sparking beryllium tools. Industrial hygiene air-sampling data for particulates are referred to in documents reviewed on-site, and have been requested from the Pantex facility.

We have reviewed swipe sample data from a variety of work areas within Line 1 for years 1970 through 1974. These data are incomplete for the periods listed and do not correspond to the entire period that AEC operations were conducted at IAAP. A 1971 summary report indicates swipe samples ranged from 0 to 1000 $\mu g/m^2$. A 1973 swipe sample report noted area concentrations from 0 to4.12 $\mu g/m^2$. A 1974 swipe sample summary noted surface concentrations of 0 to 111.6 $\mu g/m^2$. The allowable reference "limit" for surface contamination from this era was reportedly 2.5 $\mu g/m^2$. These swipe sample data are at best qualitative measures of potential for exposure to beryllium, and indicate work areas where beryllium was a recognized risk, and where air sampling data would be beneficial.

To date, LPT beryllium screening of a small subset of the IAAP workers has revealed that 5 of the 277 participants have twice tested positive for beryllium sensitization using peripheral lymphocyte transformation assays. Evidence suggests that chronic beryllium lung disease can have a long latency period and is not related to duration of exposure. An example: one of the five sensitized workers from IAAP was employed in the laundry facility at the plant for two months in 1968 and had no other potential work history exposure to beryllium, and no direct exposure to AEC processes other than handling workers' clothes. A second of these five workers was employed exclusively on DOD lines from 1959 to 1982, but was married to a Line 1 inspector.

LPT screening results that document prevalence of beryllium sensitization among IAAP plant workers appear to be comparable to several other DOE facilities. Post-cleanup wipe sample data indicating persistent surface beryllium contamination suggests the need for more comprehensive screening of this population. We have recently received and are in the process of reviewing the hard copy results from LPT assays and work histories from the 277 workers who have been screened to date via ORISE. We are in discussions with DOE and ORISE staff regarding the possibility of facilitating further beryllium screenings for this population and have made preliminary arrangements for physical facilities on-site where medical screening might be provided.

2. Radiation

Exposure to radiation was a common concern expressed by former workers with a wide variety of job titles. The topic was brought up at public meetings, during phone calls, and at focus groups. While many of the workers stated they thought their radiation exposures were well monitored, other workers voiced concerns. It is clear that many production workers and others potentially at risk were not monitored. For example, many of the security personnel stated that even though they worked around radioactive materials, they were not provided dosimetry. Several of the security guards who did not receive dosimetry recall standing by and signing for the radioactive materials when they arrived by rail. Other workers without history of monitoring provide accounts of spending their entire shift in the rooms where the devices containing radioactive materials were partially assembled. Based on the Burlington dosimetry records recently received from Pantex, it appears that only about 10 percent (~ 500 individuals) of the former AEC workers were provided personal dosimeters. A former Health and Safety Officer stated that dosimetry was "provided to the workers who had the greatest potential for exposure". However, in the event of an accident or undetected radiation release, it would have been possible for workers without dosimetry to receive non-quantifiable exposures. From interviews with some former workers who were not provided dosimetry, it was apparent the lack of dosimetry was and is a source of concern and stress. The workers without dosimetry had no assurances regarding whether or not they received detrimental radiation exposures. A former worker with no dosimetry recalled,

> "I was walking in the long hallway outside the cells where they were assembling the warheads and a blue flash occurred. One of the workers in the cell died the next day at the hospital, while another worker in the cell died a year later. I helped with the workers after the flash and I had physical problems ever since the accident."

This allegation of a possible criticality has been the topic of concern and investigation involving various governmental agencies including the US Army Corps of Engineers and Iowa Department of Public Health.

Even some of the workers who were provided dosimetry expressed concerns about their perceived exposures. A former worker with dosimetry recalled,

> "Yes, we wore film badges that would change color if we got too much radiation exposure. One day on my way out the building heading home, I saw a large number of the badges we just turned in being thrown in the trash. I really do not think they ever truthfully told us how much radiation exposure we received."

Regardless of the validity of the risks based on workers' reports, there were numerous well-documented sources of potential radiation exposures. The records received to date indicate there were a variety of radiation sources at the Burlington plant, including various nuclear weapons component materials, radiographic equipment, depleted uranium, and radon.

a. Radiation Sources

1. Nuclear Weapons Components
   The primary radiation sources at the plant were associated with the nuclear weapons component materials including uranium-238, uranium-235, plutonium, and tritium. Memoranda indicate that approximately 0.006 curies per year of tritium was released to the environment. Safety reports indicate that swipe counting and direct surveys routinely monitored removable and non-removable radioactive contamination. We have not located documentation of any of these surveys to date.

2. Radiographic Equipment
   A 1969 Health Protection Appraisal Report indicated that there were 2-1 MeV, 1-3 KeV, 1-250keV, 1-110 keV generators and a 5 and 50 Ci cobalt-60 source used at the plant for non-destructive testing.

3. Depleted Uranium
   Several recently received safety reports indicate that several pounds of uranium-238 were routinely converted to a fine oxide powder during each hydrodynamic explosive (hydroshot) test routinely performed at Firing Site 12 (FS12). It was estimated that 8,800 pounds of depleted uranium was exploded at FS12 in 701 hydroshots between 1965 and 1973. Firing site employees were responsible for picking up hot shards of depleted uranium from the firing site.

   > "We picked it up bare-handed for at least a year, then were given a cotton liner-type glove to wear, and then eventually we wore regular cotton gloves. That was after they got a geiger counter out there and saw "hits" from DU….the pieces we picked up might weigh 8 or 10 pounds, and smaller pieces (of DU) were as big as a thumbnail. We put the pieces in a box, … then put it inside a can that was sealed with lead and shipped away….It (the shots) was loud, they measured over 120 decibels, but we had no hearing protection since they called it "impact noise."

   Several workers at the firing site report that many of the people who worked at the firing sites have developed numerous types of cancer including bladder cancer. Reports suggest that direct surveys were performed at the sites for uranium including air samples and soil samples. Memoranda retrieved from files at the Burlington Plant suggest that approximately 2,000 grams per year of depleted uranium are burned at the disposal field. A 1969 Standard Operating Procedure describes protocols for burning normal or depleted uranium machine turnings intermixed with explosives or mock explosives. Burn pad ash residue containing excessive alpha contamination was to be collected in plastic bags and shipped to Pantex for burial.

4. Radon
   Former Health and Safety Officers at the Burlington Plant stated that many of the buildings, particularly underground structures, have been tested for radon gas. We have been unable to obtain the results of these tests to date. Our Year 2 plans include conducting retrospective radon testing of Line 1 buildings.

b. Exposure Records

We have just received from Pantex several thousand pages of personal dosimetry and area monitoring reports for the Burlington Plant for the years 1956-1975. The records include reports from either Tracer Labs or Landauer listing exposures to penetrating and non-penetrating radiation. The completeness of data has not been determined at this time. A superficial review of the dosimetry records suggest that the overall exposures generally were within established guidelines, but slightly exceeded the range of exposures reported for the workers at the Nevada Test Site. A quick scan of the data indicates that many of the higher exposed production workers were women. There are some reports by workers that some of the women who worked on the production line worked late into their pregnancies. A comment noted between former Line 1 workers at the first public meeting held in Burlington:

> "I don't see any of the women we used to work with…I think they've all died"

Overall, the majority of the highest yearly exposures appear to have occurred in the early 1970s. There appears to be limited monitoring of extremities. A few records retrieved from the Burlington plant suggest that a bioassay program was in place during some years for tritium analysis. These records have been requested from the archives held at the Pantex plant. Limited surface swipe data is available for "products" received during production years, and for building surfaces at the time AEC operations were closing and moving to Pantex. These will be reviewed and compared to exposure data by area when possible.

3. High Explosives

One relatively unique aspect of this cohort is the extent of exposure to various high explosives. For much of the workforce there was considerable potential for dermal and airborne exposure to agents through process of formulation, melting, pouring, packing, and extensive machining to manufacture shaped charges. Several former workers described personal or coworker episodes of extensive dermal and hair discoloration resulting from high explosives exposures. Curiously, reviews of the literature suggest this discoloration is as likely to be systemic as a local manifestation.

There has been considerable concern expressed by former workers and their families regarding possible occupational hepatotoxicity and hepatic carcinogenicity related to explosives exposures. A March 11, 1947 Intelligence Check sheet of Burlington plant operations documents one death and the loss of 39 workdays for four other workers due to systemic TNT poisoning. It is not possible to determine whether these were specific to AEC or DOD activities although one would suspect the latter to be more likely. On-site industrial hygiene and medical records received to date contain no exposure or biomonitoring data for explosives or their effects.

a. TNT 2,4,6-Trinitrotoluene

Toxic hepatitis is the principal manifestation of 2,4,6-trinitrotoluene toxicity in humans. US Army studies documented measurable effects on liver functions among workers exposed at or close to the currently accepted TLV. There may be a number of reasons for variability in individual susceptibility to such effects.

A recent case-control study of Chinese workers exposed to TNT indicated that the risk of liver injury is increased among heavy drinkers as compared to workers who are not heavy drinkers. Several studies of Chinese workers have indicated reproductive effects of TNT. Case-control studies in two TNT plants in China of effects on semen revealed significantly lower semen volumes and a smaller percentage of motile spermatozoa, as well as a significantly higher incidence of sperm malformation, in exposed compared to control workers. Controls were matched to exposed workers on income and residence. The presence of mutagenic compounds in the urine indicative of mutagenicity has been noted in several investigations of workers exposed to TNT. Urine samples collected at the conclusion of a work shift were assessed for mutagenic activity using Salmonella typhimurium and Escherichia coli strains. Evidence of mutagenic activity was present in the urine of groups exposed to TNT, but significant genotoxicity was confined to urine from individuals in the high exposure groups.

Lab animal studies have shown elevated rates of leukemia and/or malignant lymphoma of the spleen among rats exposed to TNT. A 1993 study of a German population living in proximity to two World War II era munitions plants indicates an association between increased rates of some types of leukemia and living in a town near TNT waste from these plants. The study revealed increased relative risk of acute myelogenous leukemia for both adult males and females living near the former explosives plants when compared with adults in a neighboring county. The relative risk was particularly high for individuals over 65 years of age. The relative risk for chronic myelogenous leukemia was also elevated for males, but there was only one case among females. It is not clear how many individuals in this population might have been occupationally exposed in these plants. Based on animal studies, EPA has classified TNT as a possible human carcinogen (Group C).

The appearance of cataracts is another observed effect of TNT chronic exposures. Irreversible equatorial lens opacities/cataracts have been reported in both Chinese and Finnish workers exposed to TNT for over five years. As with dermal discoloration, it is unknown whether this is a systemic or local toxicity. The progression of the cataract is observed to stop if the exposure to TNT stops. The mechanism of TNT cataract formation is not understood, but the possibility was raised that free radical formation and/or covalent binding to macromolecules may play a role. Some investigators have used hemoglobin adduct formation and excretion as measures of TNT exposure and bioeffect and as a measure of risk for toxic injury.

b. RDX Cyclonite, Hexahydro-1,3,5-trinitro-1,3,5-triazine

The predominant toxicity reported for workers exposed to RDX by the inhalation or oral routes is neurological with seizures, convulsions, confusion, muscle twitching, hyperirritability, and amnesia. One lab animal study found statistically increased incidences of combined hepatocellular adenomas and carcinomas in female mice. Otherwise, there is little information regarding potential chronic toxicity from RDX.

c. HMX Octahydro-1,3,5,7 tetranitro-1,3,5,7-tetrazocine

Octahydro-1,3,5,7-tetranitro-1,3,5,7-tetrazocine is an explosive polynitramine commonly known as HMX (derived from High Melting Explosive, sometimes called “her majesty’s explosive”). Similarly to RDX, HMX toxicity appears to be largely neurological with hyperkinesia, hypokinesia, convulsions, mydriasis, cerebral edema, and/or hemorrhage noted in laboratory animals, and animal studies suggests that HMX may exert hepatotoxicity among highly exposed individuals.

d. Tetryl Tetranitromethylaniline

Human studies of tetryl exposure indicate sub chronic occupational exposure can result in various digestive disorders including loss of appetite, abdominal pain, vomiting, and loss of weight. Tetryl exposure can induce diffuse central nervous system effects such as headaches, insomnia, exaggerated reflexes, mental excitation, malaise and fatigue. Other effects observed after oral tetryl exposure include chronic hepatitis, leucocytosis and a slight anemia. Although there have been no epidemiological studies of hepatic function in exposed workers, there have been several case reports of hepatic toxicity including fatalities among highly exposed workers. Picric acid, a metabolite of tetryl, has been associated with functional and clinical indications of liver impairment (elevated bilirubin and urobilinogen and jaundice) following inhalation or oral exposure in both animal and human exposures. The most common effects observed in workers exposed to tetryl dust (e.g., skin discoloration and dermatitis) were believed to have been caused by dermal exposure to the compound. Workers that handled tetryl in manufacturing plants frequently developed a yellow staining of the hands, face, and hair. Several former IAAP workers and or family members anecdotally recalled cases of "yellow skin," "yellow hair," or "sweating their sheets and clothes to a yellow color." In addition to dermatitis, tetryl has been associated with acute and delayed hypersensitivity reactions. Epidemiological studies revealed that workers exposed to tetryl during the manufacture of explosives occasionally developed irritability, headaches, fatigue, and insomnia.

4. MOCA 4,4'-Methylenebis(2-chlorobenzenamine)

MOCA was introduced in the mid-1950s in the production of high-performance polyurethane molded products and sealants. MOCA was used as a curing agent for adiprene, and was used extensively to bond components, with or without high explosives.

MOCA is classified as probably carcinogenic to humans (Group 2A), based on human case studies and experimental animal data suggesting causal association with bladder cancer. MOCA forms adducts with DNA, both in vitro and in vivo. Animal testing has shown risk for transitional-cell carcinomas of the urinary bladder and urethra in beagles, and lung adenocarcinomas and hepatocellular tumors in rats. MOCA was widely used in epoxy resin processes in the assembly of various components of weapons manufactured at this facility.

We have reviewed copies of correspondence among and between AEC and IAAP contractor management dated on and around 1973 involving control processes to reduce MOCA exposures following OSHA's emergency standard on carcinogens. These controls included installation of laboratory hoods, glove box operations, and negative pressure change rooms; personal protective equipment and clothing; product smear samples and employee access logs; and employee biomonitoring (urinalysis). These process and administrative controls affected employees in several work areas, including buildings 1-12, 1-40, 1-53, 1-61, and 1-63-7. To date, we have not located air sampling data to document airborne exposures.

We have thus far identified 48 employees recognized as being at risk to MOCA, based on employee urinalysis and MOCA access records. Reportedly there are additional relevant industrial hygiene and biomonitoring records available at the Pantex site and we are trying to locate and arrange for the receipt of these records.

5. Asbestos

The IAAP has two coal-fired power plants and miles of asbestos-coated steam pipe coursing the complex as well as many miles of tremolite asbestos fiberboard lined tunnels. Much of this asbestos insulation or construction material is in relative disrepair with visible friable areas upon cursory inspection. Asbestos is classified as a Class A known human carcinogen based on extensive human epidemiology data. The primary target for asbestos is the lung with chronic inhalation resulting in an interstitial fibrotic lung disease termed asbestosis. Asbestos inhalation exposure can result in all cell types of lung cancer as well as mesothelioma (a mesenchymal cancer of pleura or intra-abdomenal connective tissue), and possibly gastrointestinal cancers in humans. Asbestos's risk of lung cancer is well known to be synergistic with risk from tobacco use, hence a recognized need for and potential benefit from secondary prevention in the form of smoking cessation.

Contract workers and maintenance employees at BAECP were involved in constructing and installing miles of asbestos board structures. Per one security guard at a public meeting:

> "We were around all those people drying the asbestos … I remember being around where the asbestos was drying.. We'd sweep the dust off each other's clothes. We wore our uniforms home, we (guards) didn't have laundry service."

A BAECP maintenance engineer recalled installing "all those asbestos boards", expressing concern about exposures experienced by his work cohort. Back then "everybody smoked."

Awareness of asbestos hazards and locations is quite prevalent among many BAECP workers, as are their recollections of acquaintances or former coworkers they believe died of lung cancer.

6. Noise

Area noise surveys are available for several Division B/Line 1 locations, including firing sites. Earliest data currently available date to the mid 1960s and reflect noise levels in machine shops, fabrication areas, explosives machining areas, and assembly. Surveyed noise levels exceeded 90 dbA and/or 85 dbC in many production and maintenance areas. Noise data do not appear to have been regularly collected, but may have been in response to complaints or implementation of special processes, such as construction jack hammering, or operating concrete saws. Hearing protection was used in a few areas, but at this point we do not have records or data that show widespread use or policies for hearing protection in general production areas. As mentioned previously in one employee's account of firing site exposures, impact noise was not necessarily regarded as problematic. Our current compilation of area noise exposure data is included in Table 1. We hope to find more information regarding noise exposures in Pantex records. Most noise exposure controls reviewed to date have addressed hearing protection rather than engineering controls.

7. Silica

Silica exposures were part of weapons production operations at IAAP, but were likely common during construction activities that involved concrete floor sawing and replaning, sand-blasting in preparation for painting, or masonry work. No exposure data has been identified to date specific to silica or respirable dust exposures. However, other industrial hygiene data referencing noise and carbon monoxide exposures during operation of jackhammers indoors, or gas-powered engines for concrete planing or sawing indicate that silica exposures existed. Several production workers have referred to cutting and resurfacing concrete floors for specific activities and uses throughout Line 1.

8. Solvents

Solvents were used extensively during the entire span of AEC production activities at IAAP. Solvents were used to clean component parts upon receiving and during production and assembly operations. Common solvents involved in production included but were not limited to acetone, toluene, alcohols, methyl isobutyl ketone, and xylene. Solvent use was also documented during equipment and floor cleaning operations. We have limited industrial hygiene data regarding solvent exposures during routine production uses. Measured exposures at times exceeded the then-Threshold Limit Values in particular at operations where solvents were heated in kettles (building 1-05) or were used in areas without exhaust hoods. We expect that a large number of production employees may have had some exposure to solvents, since they were so widely used in most stages of component and equipment cleaning. Safety department memos indicate recommendations for use with local exhaust when possible. References to respiratory protection and/or gloves were not noted in documents we have found to date.

Risk Mapping

We gathered "expert" former and current workers in focus groups to obtain in-depth information about the industrial processes and exposures across the plant and the BAECP facility changes over the years. We obtained detailed schematic maps of the facility and are in the process of matching it to lists of processes, products, and exposure data to develop a risk map. A table summarizing location, process, exposure, and timeline data follows. This table is periodically revised as we accumulate new exposure data or review documents that provide information regarding process or building use, safety measures, or personnel information.

Risk Map: Locations, Processes and Exposures at BAECP

Building Number	Description	Use	Exposures/Comments
1-01	Maintenance shops "Pipe shop" "Tool and Gauge Shop"	Fabrication Millwrights, maintenance shops, carpenter, electric, pipefitters	Asbestos; Solvents; Dusts; Metals; Acids; Noise • High noise data from 1-01 pipe shop, grinders on site • Acid exposures during handling noted
1-02	Boiler house		Asbestos; Petroleum distillates; CO (natural gas & fuel oil byproducts); Noise; Chromates • Employees may not have needed Q clearance?
1-03	Water Lab	Chemical analysis lab	Solvents / Adhesives; Acids • Documented employee complaint related to use of adiprene.
1-03-2 1-03-3 1-03-4 1-03-5 1-03-6 1-03-7	Solvent storage		Solvents • Above—ground solvent storage – 25K gallons per 1979 records
1-04	Developmental lab aka Chem. Lab & Health and Safety Offices & Information Retrieval Office	Chemical analysis lab on the south end, maintenance on the north	Solvents, various chemicals, Metals, Plastics; Acids; Isocyanates; MOCA • Army built it for metal parts assembly but this building turned into a chemistry lab around 1950 • Chromic acid plating; adiprene use; documented complaints attributed to isocyanates • MOCA operations
1-05-1 1-05-2	Melt & Pour areas "Center of Line"	Melt of composition B, TNT and barium shapes	Explosives; Solvents; Noise; Silica • Explosives melting through mid-late 60s (~ 1967-68)

			• Document of melt workers exposed to acetone during boiling
1-06-1 1-06-2	Powder Prep	Powder (explosives) receiving	Explosives • Powder prep including TNT, Comp B, RDX, A-6, in powder or flake form.
1-07	Storage/service magazine		
1-08	Explosive Inspection & Screening Building		Explosives • Screened here for metal parts, then by conveyor to melt area
1-10	Explosives Press and Machining	Explosives pressed beginning mid-to-late 1960s. (TNT, RDX, HMX)	Explosives; MOCA/adiprene; Solvents Silica • Small explosives press was located here. • Hood and glove box installed for handling MOCA – 1973.
1-11	Vault Storage for Components (pits)	Received & unloaded pits, some assembly	Radiation; Beryllium • 1970s radiation swipe data indicates contamination at squash press area, squash removal area • Building had stationary air monitors T336, T289, and/or T290 (tritium) • Beryllium swipe data
1-12	High Explosives Fabrication, Pressing, and Machining	Explosives pressed beginning mid-to-late 1960s. Held "glue bays" and large presses	Explosives; MOCA/adiprene; Solvents; Radiation; Noise • Explosives were screened for metal parts here. • Bay Z had the Big Elmes Press. • High explosives machining underwater • P-61, P-81s, P-261 job classifications here. • MOCA logs document employee entry and exit • Glove box installed for

			handling MOCA – 1973. • Radiation swipe sampling performed 1972-75. • 1968 Noise level at 99 dbA
1-13	Assembly Area Uranium 235 pits		Radiation • Assembly of larger nonplutonium weapons (U235) detonators and covers • Radiation swipe data – 1974 for Bays A-G.
1-15	Staging area	Storage area for HE	• Half hemispheres and other components brought pending load limits
1-18	Research and Development		Beryllium; Radiation • Beryllium swipe data • References to disposing of radioactive waste from 1-18 – 1971.

1-19	Assembly bays	"Experimental building" 1-19-1 through 1-19-7 were igloos Built just before AEC left, and supposedly not used by AEC	Radiation MOCA Beryllium • Had T289 (tritium) monitors—open ionization chambers • A 1973 inter-office memo indicated 1-19-7 was a MOCA-area requiring cleaning at the mixing station and oven in hallway. • Beryllium swipe data 1974
1-40	High Explosive Machining & Waste Treatment Facility	An underground building. Machining of explosives from press or melt areas. Held "glue bays"	MOCA/ adiprene; Solvents; Adhesives; Radiation; Barium nitrate; Explosive residue; Oil mists; Barium nitrate; Noise; Silica • Used lathes and delta machines, machined explosives to shape "under water". • 1971 memo –complaint of oil mist fumes @ Heald machine bays. • MOCA/adiprene access logs. • Hoods & glove boxes installed for handling MOCA, HE – 1973. • 1-40 bays & equipment room – high noise exposures • Barium nitrate data - 1972 • Radiation swipe data available for bays G, H, J, and Q – 1974. • Waste water treatment for HE • Noise data related to breaking concrete floor – also silica exposures • References to disposing of radioactive wastes from building 1-40 – 1971 document
1-50	Roundhouse (Transfer Building)	Powder Receiving / Prep	Explosives • Powder (may include TNT,

			Comp B, RDX, A-6) received at 1-50 roundhouse, then went to 1-08 then 1-06 bldgs for MOCA blending • "diesel fueling station south of roundhouse along main track… spills due to overloading vehicles… paint done in paint booth with lead-based paints,…timbers dipped in creosote… transformers stored…."
1-51			VOCs? • Employee complaint documented related to a product used in air conditioner cleaner

1-52		Master Mechanic's office	Noise • "Addressograph 88 dbA at operator head" – 1969
1-53	Research and Development "Plastics Lab"	Used this to pour MOCA and adiprene after building 1-60	MOCA/adiprene; Solvents • MOCA casting & molding • Glove box installed for handling MOCA – 1973 • MOCA clean up - 1973
1-55	Communications center		
1-60	MOCA blending / Plastics Laboratory	Poured MOCA and adiprene, blended MOCA into the HE	MOCA/adiprene; Isocyanates; Explosives ; Noise • "A lot of barium nitrate was handled at 1-60 building. There was anthracene or P-naphthalene used as an anti-cracking additive and also in some inert load formulations which was toxic (carcinogenic impurities); green dye used, LX-09 (FEFO) is believed to be toxic but readily decomposed." • 1965 health protection survey reference to significant isocyanates & TNT air sampling results • 1968 Noise data –jack hammering – to 114 dbA
1-61	Assembly Area U235 pit assembly	Non-plutonium bearing weapons (i.e., uranium) A 2-level building	Radiation; MOCA/adiprene; Solvents; Beryllium; Noise • Had T336, T289, and/or T290 monitors for tritium (air monitors) • MOCA/adiprene logs for employees in 1-61 bays J & K; Hood ventilation and process controls implemented for MOCA handling, 1973. • Had a worktable "but no machining on Be. However people could have used a file on their Be tools."

			• Beryllium swipe data

1-62	Boiler house aka Power house	No Q clearance required	Petroleum distillates, VOCs; (natural gas and fuel oil byproducts); CO; Noise • 1971 memo: 2 major sources of pollution from AEC facilities are Div B Disposal field **and 1-62 power house** • 1-62 powerhouse burned natural gas and fuel oil
1-63	Operating Bays & Assembly Cells (1-63-1 through 1-63-6) Plutonium pits (post 1956)	Cells with gravel gerties:	Radiation, Beryllium, Solvents Noise • Built after 1957 as area to bring together explosives and plutonium physics package. (Prior to 57, inserted fissionable material in flight.) • Be swipe data from buildings 1-63-1 through 1-63-7. • Had T336, T289, and/or T290 monitors for tritium (air monitors) • 1969 Hallway noise up to 89 dbA
1-63-7	Assembly Cell	Gravel gerty	Radiation; MOCA/adiprene; Solvents • Hood and glove box installed to control MOCA exposures -1973
1-64	Storage (1-64-1 through 1-64-5)	Including pit storage	Radiation; Beryllium • Radiation swipe data – 1972-74 • Beryllium swipe data
1-65			Radiation • Radiation swipe data – 1972-74
1-66-1 1-66-2	Storage		Radiation; Beryllium • Structures for storage of finished items • Radiation swipe data – 1972-73 • Beryllium swipe data, 1974

1-67	(1-67-1 through 1-67-3)		Radiation; Beryllium • Radiation swipe data – 1972-74. • Beryllium swipe data 1974.
1-69			Beryllium • Beryllium swipe data
1-70	Vacuum drums / Staging Area		Explosives residue; Noise; Solvents; Silica • Big vacuum drum for salvaging explosive residue from machining-water waste • Explosives went to 1-70 building then 1-12 for screening and pressing salvaged explosive residue • Filtered metal-working fluids (activated carbon used on water from 1-40 building)

1-71	Explosives Storage		Explosives
1-73	Storage and Receiving	Storage and receiving in early years until approx. 1957; then used as pit storage 1957 to late 60s	Radiation • Raw materials (pits) were coming to 1-73 when JS started, 1958. • Nuclear weapons built in 1-73 until 1-63 building was built. • Then 1-73 was used as storage area for pits.
1-74	Explosives Storage		Explosives
1-75	Explosives Storage		Explosives
1-77	Pit Storage and Inspection	Pit receiving & inert assembly, built in mid-60s	Radiation; Beryllium • Radiation swipes & air sampling data • Tritium bottles were charged here • Beryllium swipe data
1-80			Radiation; Beryllium • Radiation swipes data 1974 • Beryllium swipe data 1974
1-84	Office / various labs	Gage block room; Physical lab; Electrical Lab	
1-85-2			Radiation? • For subcomponents of depleted, center items. Building built but not used by AEC
1-99	Dust collection building		Explosives; Metals • Dust collection from explosives machining operations. Some recycling of collected product when possible depending on configuration.
1-100	X-Ray	Linitron x-ray -	Radiation • X-Ray explosives for air cavities
1-100-1	X-Ray	X-ray facility and film development center	Radiation • X-Ray explosives for air cavities

1-100-2	X-ray	X-ray built for Linitron accelerators	Built, but was not used
1-136	Bomb shelter		
1-137-1 1-137-2	Change House / Cafeteria		Explosive and other dust residue? Radiation? • Clothing Changed prior to working in contaminated areas • Radiation swipe data 1971-75
1-137-4	Main Kitchens & Cafeteria / Administration Building Cafeteria		Beryllium? • Used as cafeteria in 1960s • Beryllium swipe data
1-152-(5,6,7,8) & (-10, 11, 12, 13)			Underground storage, fuel oil #6 per 1979 records
1-169-C4A	Store		
1-172	Office / Standards Lab		
1-180-1	Storage area		

1-DIE	Tool & Dye		Noise; Beryllium
AX-1 AX-2	Badge houses	Where people went to get into restricted areas	
FS-6	Firing site		Noise; Metals; Gaseous combustion by-products; Explosives residue • AEC used this firing site but no hydroshots fired on FS 6
FS-12	Firing site	hydroshots	Noise; Depleted uranium (DU); Metal fumes; Gaseous combustion by-products; Explosives residue • Fired 701 hydroshots that contained depleted uranium • FS12 employees had to pick up DU pieces by hand, put in boxes, then cans, seal with lead and ship away. No gloves • DU caught fire, often shot beyond fire barrier/perimeter into woods or fields; some not cleaned up outside fire barrier • High noise, > 120 db, impact. 1 –2 shots/day • Cancer cohort?
Yard B "Burn Area" (BG-2)	AEC Explosive Disposal Area (EDA)		Explosives dust, Metals residue; Solvents; Fuel oil byproducts; HE-contaminated uranium 238 dust (per health & safety survey) • "Flashing material" referred to burning materials contaminated with explosives, before being scrapped to the public. During machining operations, explosive material would accumulate in cracks and crevices of machines • used as explosive storage magazine for all types of scrap for many years for both Division A & B operations • 1971 memo: Division B

			Disposal field… major source of air pollution from the AEC facility

Yard G			Radiation? Explosives residue? • S. Cotner of St. L Army Corps of Engineers notes Yard G used by AEC – per declassified documents • "nothing other than spillage and cleaning up bulk explosives"
Yard L	AEC Inert Storage		Lead; Metals; Solvents; Petroleum distillates; Various exposures • "battery operated forklift repair storage and battery reworking at the 51 bldg. Stored inert materials, solvents, PCB boxes, projectiles in containers and there was oil spillage at the powerhouse south of the old water tower. Also at the powerhouse for Whses 1,2,3 and generator building in that area, there would be #2 fuel oil and solvent storage."
?	Laundry facilities	Outside Line 1	Explosive residue; Silica; Asbestos; Radiation; Beryllium • Anecdotal accounts of laundry workers handling AEC worker clothing – returned clothes in same carts dirty ones came in