World Trade Center Health Program

Summary of Evidence

For

Establishing Dates on which Cleanup of the Pentagon and Shanksville, Pennsylvania Sites of the Terrorist-Related Aircraft Crashes of September 11, 2001 Concluded

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Executive Summary

Section 3311(C)(i)(I) and (II) of the James Zadroga 9/11 Health and Compensation Act of 2010 (Zadroga Act) requires the Administrator of the World Trade Center Health Program (WTCHP) to determine dates of eligibility for enrollment in the World Trade Center Health Program for individuals who were members of a fire or police department (whether fire or emergency personnel, active or retired), worked for a recovery or cleanup contractor, or were a volunteer; and performed rescue, recovery, demolition, debris cleanup, or other related services at the Pentagon in Arlington, Virginia or the Shanksville, Pennsylvania, sites of the terrorist-related aircraft crashes of September 11, 2001. Specifically, the Zadroga Act requires the Administrator to determine the dates on which cleanup of the Pentagon and Shanksville sites of the terrorist-related aircraft crashes of September 11, 2001, concluded.

To develop information and evidence of the concluding dates for cleanup activities at these two sites, an extensive literature search was conducted, requests for information were sent and conference calls were held with response participants (e.g., fire departments; Somerset County; Pennsylvania coroner; Pentagon Renovation Program; U.S. National Park Service; United Airlines; and others), and a face-to-face meeting was held with local volunteer fire departments in and around Shanksville. In addition, available informational documents (e.g., Arlington County after-action report, Department of Defense [DOD] Historical Office book, journal articles, and individual accounts of events) were reviewed.

Pentagon Site

Beginning on September 11, 2001 the Arlington County Fire Department (ACFD) led the fire and rescue phase of the Pentagon response. On September 21, 2001, the ACFD relinquished control of the site to the Federal Bureau of Investigation (FBI), and the site was officially designated a crime scene. At that time, one fire fighter company, a technical rescue team, and paramedics remained at the site until the site was turned over to DOD. The FBI continued their crime scene investigation until transferring control of the site to Washington Headquarters Services (a DOD Field Activity). Differing accounts of the date of the transfer place it on either September 26, 2001, or September 28, 2001.

On October 2, the Pentagon Renovation Program (a Washington Headquarters Services office) controlled the site and began preparations for demolition and cleanup of the impact area. However, these activities were delayed until after October 11, 2001, when the first memorial service for the victims of the attack was held. The demolition/cleanup phase of the project began on October 18, 2001, and was completed on November 19, 2001. Cleanup activities began on September 12, 2001 with a contractor cleaning soot, smoke, and water-soaked

materials from inhabitable areas of the Pentagon in preparation for returning employees. Numerous law enforcement agencies responded to the Pentagon in support of the Arlington County Police Department, the Pentagon Defense Protective Service (federal law enforcement personnel whose jurisdiction includes the Pentagon), and the FBI. Response activities included rescue efforts, site security, traffic control, and evidence collection. The contribution of volunteers to the Pentagon response cannot be captured in its entirety, as thorough records are not available. The American Red Cross was a major contributor and many other volunteers played a role throughout the response.

A number of different groups conducted pre- and post-cleanup environmental sampling. Employees began to return to work on September 12, 2001; therefore, the sampling focused on their work areas. Most of the samples collected were area samples; however, some personal sampling was conducted. Much of the data from these sampling efforts are documented in a report from the U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM). This report's conclusions suggest that contamination was concentrated at the incident site and most of the environmental samples collected, especially post-cleanup, were below occupational health or environmental standards.

Most of the fire department personnel left the site after it was turned over to the FBI on September 21, 2001, except for the one fire fighter company, a technical rescue team, and paramedics. Fire department presence continued at the Pentagon until the site was turned over to DOD on September 26, 2001, or September 28, 2001. The available information does not indicate what period of time fire department personnel were onsite from the end of September until the completion of demolition and cleanup activities on November 19, 2001.

The available literature indicates that police departments had a presence at the Pentagon until the site was turned over to DOD on September 26, 2001, or September 28, 2001. The literature suggests that after the site was turned over to DOD, many of the services typically provided by police departments were handled onsite by military police or by Defense Protective Service personnel. However, the available information does not indicate whether police department personnel were onsite from the end of September until the completion of demolition and cleanup activities on November 19, 2001.

Recovery or cleanup contractors were onsite at the Pentagon until November 19, 2001, which is the date demolition activities concluded. This information is referenced in numerous documents and the Pentagon Renovation Program.

The available information does not provide a complete listing of all volunteers onsite, or the timeframes of their participation. It is reasonable to conclude that at least some volunteers were onsite through the crime scene phase of the response, ending on September 26, 2001, or

28, 2001. However, the available information does not indicate whether volunteers were onsite during the demolition and cleanup phase of the response.

The available information has substantial uncertainties that limit the ability to determine with absolute precision specific end times for each group's activities at the site. To ensure that those who did respond are provided adequate opportunity for medical monitoring and treatment benefits, WTCHP eligibility is recommended for the period covering September 11, 2001 through November 19, 2001 for individuals who worked for a fire department, a police department, or a recovery or cleanup contractor, or were a volunteer, and performed rescue, recovery, demolition, debris cleanup, or other related services at the Pentagon site of the terrorist-related aircraft crash of September 11, 2001.

Pentagon Site Concluding Date: November 19, 2001

Shanksville Site

Beginning on September 11, 2001, the FBI controlled the site and declared it a crime scene. After 13 days of work on-site, the FBI relinquished control of the site to the Somerset County Coroner on September 24, 2001.

The nature of the site did not require a fire and rescue response phase although fire and police departments were among the first to respond by extinguishing localized hot spots and brush fires while Pennsylvania State Troopers provided security.

During the last weekend of September 2001, the Somerset County coroner enlisted the assistance of approximately 300 personnel (volunteers, fire fighters, police, and the Pennsylvania Region 13 Counter-terrorism Task Force [task force of 13 counties in western Pennsylvania]), the State Funeral Directors Association, and other volunteers to conduct "Operation Clean Sweep," which involved scouring the area to pick up remaining aircraft parts and flagging any objects resembling human remains. The contribution of volunteers to the Shanksville response cannot be captured in its entirety, as thorough records are not available. The American Red Cross was a contributor, and many other volunteers played a role throughout the response.

After the response to the crash was completed, United Airlines contracted Environmental Resources Management, Inc. (ERM) to reclaim the site. Site characterization for potential aircraft-related contaminants was conducted according to Pennsylvania environmental law. ERM concluded that surface soils, subsurface soils, and ground water beneath the site did not exceed any state health standards and did not require any remediation. Additionally, none of the surface water results indicated any contamination that could be attributed to the Flight 93

crash. ERM backfilled the crater between October 1, 2001, and October 3, 2001. The site was restored as close as possible to its original appearance; 4–6 inches of topsoil was added on top of the crater and through the forest area, and the area was seeded with flowers and grasses. ERM continued monitoring ground water until mid-2002.

The Somerset County coroner indicated that in the years following the response, the Pennsylvania National Guard and Camp Cadet (camp for youth operated by the Pennsylvania State Police) had been out to the site to collect aircraft parts.

Most of the fire and police department personnel and volunteers left the site after the FBI turned the site over to the Somerset County coroner on September 24, 2001. However, fire and police department and volunteer presence was limited at the Shanksville site until the conclusion of the final sweep of the crash site for aircraft parts and potential human remains on September 29–30, 2001. Available information suggests that law enforcement personnel remained at the site to provide security for a number of years. The available information does not indicate whether fire department personnel or volunteers were onsite during the site restoration activities from October 1–3, 2001.

Available information indicates that environmental restoration contractors restored the site close to its original appearance from October 1–3, 2001, signaling the conclusion of the response.

The available information has substantial uncertainties that limit the ability to determine with absolute precision specific end times for each group's activities at the site. To ensure that those who did respond are provided adequate opportunity for medical monitoring and treatment benefits, WTCHP eligibility is recommended for the period covering September 11, 2001 to October 3, 2001 for individuals who worked for a fire department, police department, or a recovery or cleanup contractor, or were a volunteer, and performed rescue, recovery, demolition, debris cleanup, or other related services at the Shanksville site of the terrorist-related aircraft crash of September 11, 2001.

Shanksville, Pennsylvania Site Concluding Date: October 3, 2001

Contents

Abbreviations

ACFD	Arlington County Fire Department
ACPD	Arlington County Police Department
ACGIH	American Conference of Governmental Industrial Hygienists
API	American Petroleum Institute
BTEX	Benzene, toluene, ethylbenzene, and xylene
CDC	Centers for Disease Control and Prevention
CO	Carbon monoxide
CO_2	Carbon dioxide
COPC	Constituents of potential concern
DOT	Department of Transportation
DPS	Defense Protective Service
DRO	Diesel range organics
EPA	Environmental Protection Agency
ERM	Environmental Resources Management, Inc.
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
FOUO	For Official Use Only
GRO	Gasoline range organics
H_2S	Hydrogen sulfide
HVAC	Heating, ventilation, and air-conditioning
IARC	International Agency for Research on Cancer
mg/kg	Milligrams per kilogram
mph	Miles per hour
MRO	Motor oil range organics
MSC	Medium-specific concentration
MWAA	Metropolitan Airport Authority Fire Unit
NIOSH	National Institute for Occupational Safety and Health
NMCC	National Military Command Center
NMRT	National Medical Response Team
NO_x	Nitrogen oxides
NPS	National Park Service
NTSB	National Transportation Safety Board
O_2	Oxygen
OEL	Occupational exposure limit
OSHA	Occupational Safety and Health Administration
PADEP	Pennsylvania Department of Environmental Protection
PAH	Polycyclic aromatic hydrocarbon
PCB	Poly-chlorinated biphenyls
PENREN	Pentagon Renovation Program
PFAC	Pentagon Family Assistance Center
PPE	Personal protective equipment
ppm	Parts per million
PTSD	Post-traumatic stress disorder

REL	Recommended exposure limit
SCBA	Self-contained breathing apparatus
SMART-PM	Special Medicine Augmentation Response Team-Preventive Medicine
SMART-SM	Special Medicine Augmentation Response Team-Stress Management
SVOC	Semivolatile organic compound
TCL	Target compound list
THC	Total hydrocarbons
TPH	Total petroleum hydrocarbons
TLV	Threshold limit value
TRT	Technical rescue teams
USACHPPM	U.S. Army Center for Health Promotion and Preventive Medicine
VOC	Volatile organic compounds
WHS	Washington Headquarters Services
WTC	World Trade Center
WTCHP	World Trade Center Health Program

Purpose

Section 3311(C)(i)(I) and (II) of the James Zadroga 9/11 Health and Compensation Act of 2010 (Zadroga Act) requires the Administrator of the World Trade Center Health Program (WTCHP) to determine dates of eligibility for enrollment in the World Trade Center Health Program for individuals who were members of a fire or police department (whether fire or emergency personnel, active or retired), worked for a recovery or cleanup contractor, or were a volunteer; and performed rescue, recovery, demolition, debris cleanup, or other related services at the Pentagon or the Shanksville, Pennsylvania, sites of the terrorist-related aircraft crashes of September 11, 2001. Specifically, the Zadroga Act requires the Administrator to determine the dates on which cleanup of the Pentagon and Shanksville, Pennsylvania sites of the terrorist-related aircraft crashes of September 11, 2001 concluded.

The purpose of this document is three-fold: (1) to identify the important response and cleanup events after the attacks at the Pentagon and Shanksville sites, (2) to identify the dates that response cleanup activities ended at the Pentagon and Shanksville sites, and (3) to provide information on the potential exposures to responders and volunteers during response and cleanup activities at the Pentagon and Shanksville sites after the attacks.

This report contains six appendices (A–F). Appendix A refers to the section about Jet A fuel. Appendices B and C include lists compiled by the report author of responders for the two incidents. Appendices D, E, and F contain references organized by topic (Exposure Publications, Mental Health Publications, Other Related Publications).

Pentagon Response

Background

Construction on the Pentagon began on September 11, 1941, and finished on January 15, 1943 [Goldberg et al. 2007]. It consists of five wedges (W1–W5), five concentric rings A (innermost)–E (outermost) five floors, and 10 corridors connecting rings and floors. The exterior walls are 921 feet long, the five inner walls are 362 feet long, and each of the five rings is 50 feet deep [Goldberg et al. 2007]. In between each ring is a space open to the outdoors and a large courtyard in the center. Between the B and C rings is the 40-foot wide A–E drive for vehicle access into the facility [Goldberg et al. 2007]. Figure 1 presents a general layout of a floor of the Pentagon. The facility has approximately 6.6 million square feet of floor space [Goldberg et al. 2007]. In 2001, the Pentagon was undergoing an extensive modernization project that began in the 1990s. At the time of the attack, the Pentagon was days away from completing all renovations in Wedge 1 and had reoccupied 3,800 employees. Renovation in Wedge 1 (begins between corridors 1 and 3 and ends between corridors 4 and 5 [Figure 1]) included removal of asbestos, utilities, and walls and upgrades to the exterior wall and windows. Renovation work had begun in Wedge 2, but 700 employees continued to work in the space [Goldberg et al. 2007].

Impact

American Airlines Flight 77 crashed into the Pentagon, killing 184 people (59 onboard and 125 within the Pentagon) just before 9:38 a.m. on September 11, 2001. Flight 77, a Boeing 757 (124-foot wing span, 155 feet long, and weighing 180,000 pounds [Goldberg et al. 2007]) impacted the Pentagon approximately 14 feet above the ground close to Corridor 4 in Wedge 1 [Vogel 2007]. It was traveling at 530 mph and carried 5,300 gallons of fuel; of that fuel load, approximately 700 gallons ignited outside of the Pentagon [Creed and Newman 2008]. The plane struck just inside Corridor 4 and passed through the newly renovated Wedge 1 and into Wedge 2; the entire event took less than 0.8 seconds [Goldberg et al. 2007; Creed and Newman 2008]. Considerable damage was inflicted in rings C, D, and E; rings A and B received little damage [Vogel 2007]. Of the 125 persons who died within the Pentagon, 92 were located on the first floor, 31 on the second floor, and two on the third floor [Goldberg et al. 2007]. Figure 1 provides the areas of the Pentagon affected by the impact of the airliner.

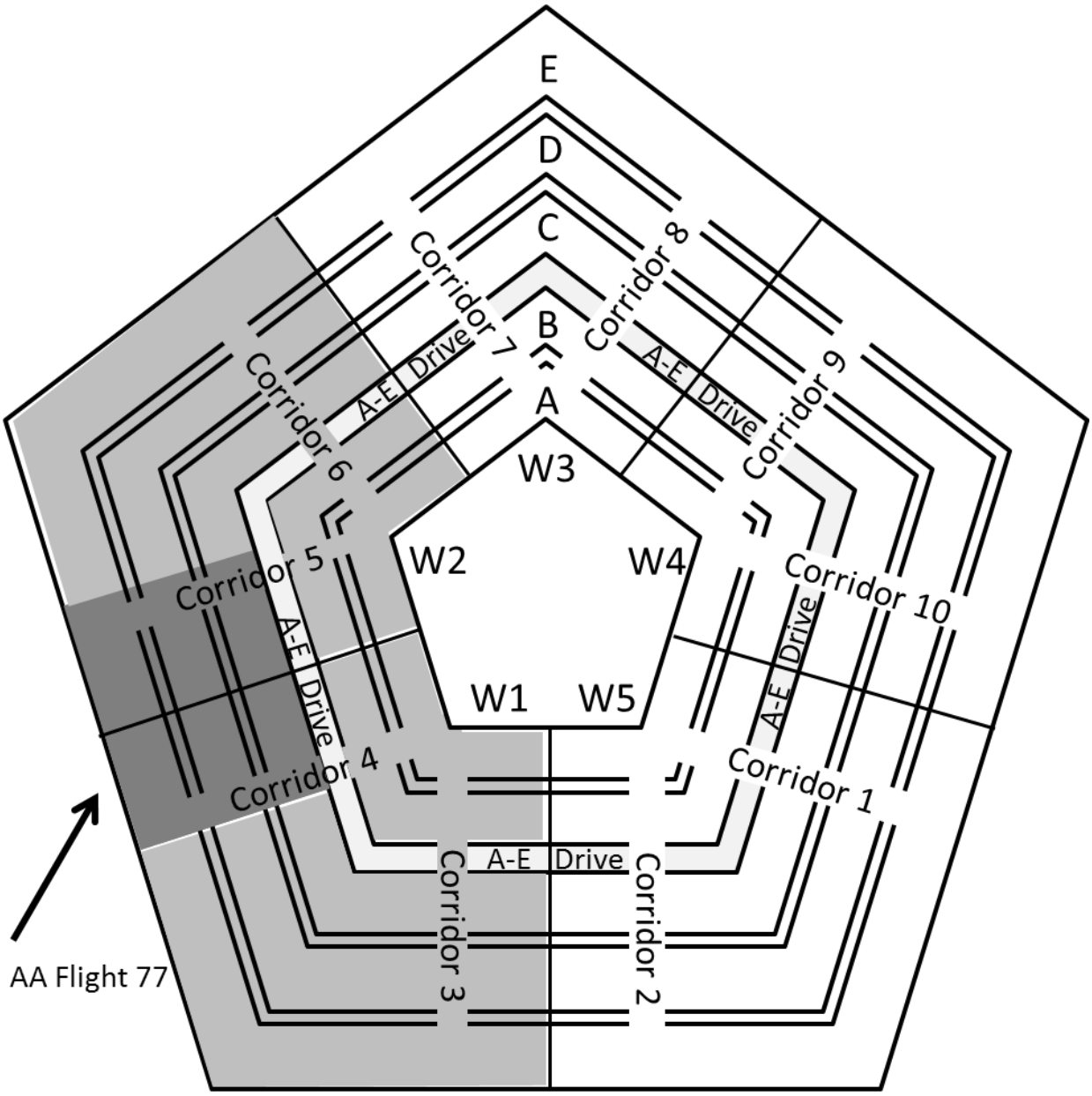

Figure 1. Basic floor plan of the Pentagon. Not to scale.

Response

Fire departments responded onsite at the Pentagon within just a few minutes of impact. Once onsite, the ACFD served as the incident commander during the fire and rescue phase of the response [Titan Systems Corporation 2002; National Commission on Terrorist Attacks Upon the United States 2004; Goldberg et al. 2007]. An estimated 300 fire fighters responded to the

Pentagon within 2 hours, and an estimated 60 agencies responded within the first 8 hours of the incident [Ward 2002; FEMA 2004]. Many volunteer fire departments played a role in the response by responding directly to the Pentagon or backfilling other stations by mutual-aid agreements [TriData Corporation 2002]. The National Volunteer Fire Council provides information on the volunteer fire departments that responded, the number of fire fighters that responded, and how they responded; at the scene or backfill, or both [TriData Corporation 2002]. An estimated 4,000 people were officially badged and were able to access the site [Goldberg et al. 2007]. Initial actions included fire fighting activities and removal of victims from the building. Foam trucks designed for jet-fuel fires were used on the resulting fire [Creed and Newman 2008]. In addition to the jet fuel, an outside 2,000-gallon fuel tank used for the ongoing reconstruction ignited from the crash [Ward 2002]. The new sprinkler installed in Wedge 1 helped limit the spread of fire [Goldberg et al. 2007]. Fire fighters battled the burning roof for more than 24-hours before it was finally under control [Ward 2002]. In addition to the 125 Pentagon employees who died in the attack, 106 employees were injured and sent to area hospitals; 49 were admitted and 57 were treated and released [Titan Systems Corporation 2002; Goldberg et al. 2007]. Estimates of the intense heat generated from the jet fuel (Jet A fuel) and burning debris range from 1,000°F–2,000°F [Goldberg et al. 2007; Vogel 2007; Creed and Newman 2008]. More information on Jet A fuel is provided in Appendix A.

Around 10:00 a.m. on September 11, 2001, the E ring collapsed pulling down floors 2–5 [Goldberg et al. 2007]. The first shoring activities began in the evening hours of September 11, 2001. USAR teams and U.S. Army personnel shored 42 columns on the first floor, six on the second floor, and another 40 received partial shoring [Ward 2002; Goldberg et al. 2007]. Four USAR teams worked 12-hour shifts (two on day shift and two on night shift), 24 hours per day, 7 days per week, thus providing 180 personnel per shift along with 60 U.S. Army personnel [Martinette 2002; Titus 2002]. During shoring and recovery activities, structural specialists monitored the area to ensure the safety of responding personnel; no serious injuries occurred during the USAR activities [Martinette 2002; Titus 2002]. USAR activities concluded on September 20, 2001 [Martinette 2002].

Many different law enforcement agencies were involved in the response. Mutual-aid agreements (Northern Virginia Law Enforcement Mutual Aid Agreement and the Northern Virginia Sheriffs Mutual Aid Agreement) facilitated the response of officers and deputies from surrounding police departments [Titan Systems Corporation 2002; Goldberg et al. 2007]. The DPS (federal law enforcement personnel whose jurisdiction includes the Pentagon) were actively involved in the rescue of employees and security of the Pentagon during the response [Goldberg et al. 2007]. The Arlington County Police Department jurisdiction includes the areas surrounding the Pentagon and therefore had a significant role in response activities, which

included working with the FBI evidence recovery operations [Titan Systems Corporation 2002]. Local police provided helicopter support during the response (e.g., U.S. Park Police Aviation Unit) [Goldberg et al. 2007]. Many law enforcement personnel spent the initial stage of the response controlling traffic in and around the area to ensure that responders could quickly get into the site and, Pentagon employees could exit the grounds and to control access to the grounds from major interstates [Goldberg et al. 2007]. The literature suggests that after the site was turned over to DOD, many of the services police departments provide were handled onsite by military police or by DPS personnel [Goldberg et al. 2007]. Military police remained at the Pentagon for roughly 2 years after September 11, 2001 [Goldberg et al. 2007].

Human remains from the Pentagon were recovered in two ways – locating/removing human remains from the building and sifting through debris in the north parking lot [Goldberg et al. 2007]. As human remains were found within the Pentagon, the areas were marked so the FBI could catalog the location and remove the human remains to the temporary morgue at the north parking lot for further cataloging, as this was a crime scene [Titan Systems Corporation 2002]. Human remains were then moved to Fort Belvoir, Virginia and then flown to Dover Air Force Base in Delaware to be identified [Titan Systems Corporation 2002]. Recovery of human remains was not finished until September 26, 2001 [Goldberg et al. 2007]. The first four victims were identified on September 16, 2001, and the final victim identification was concluded on November 15, 2001; five victims were not identified on the basis of the available human remains [Goldberg et al. 2007]. More than 700 FBI agents participated in the recovery phase and the crime scene investigation phase of the response [Titan Systems Corporation 2002; Goldberg et al. 2007].

Secretary Rumsfeld declared that the Pentagon would be operational on September 12, 2001, and several thousand employees arrived for work the next day [Goldberg et al. 2007]. By September 24, 2001, two-thirds of the Pentagon was reoccupied (area between Corridor 6 ½ to Corridor 2 ½ [clockwise]) [Goldberg et al. 2007]. On September 21, 2001, the ACFD relinquished control of the site to the FBI. At that time, one fire fighter company, a technical rescue team, and paramedics remained at the site until the site was turned over to DOD [Goldberg et al. 2007]. The FBI continued their crime scene investigation until turning control of the site over to WHS on either September 26, 2001, [Goldberg et al. 2007] or September 28, 2001 [Titan Systems Corporation 2002]. On October 2, 2001, PENREN controlled the site and began preparations for demolition. However, demolition activities were delayed until after the first memorial service was held on October 11, 2001 [PENREN 2002; Goldberg et al. 2007]. The demolition/cleanup phase of the project began on October 18, 2001 [Goldberg et al. 2007]. During the demolition phase, 400,000 ft^2 of material (56,000 tons of debris) from rings C, D, and E between corridors 4 and 5 was removed and taken to landfills [Vogel 2007; Pentagon

Memorial Fund 2011]. Approximately 450 workers working two 12-hour shifts, 24-hours a day, 7 days a week completed the demolition phase of the project on November 19, 2001 [Goldberg et al. 2007].

The reconstruction phase of the Pentagon (nicknamed Project Phoenix) employed 3,000 workers working two 10-hour shifts, 6 days per week. The final concrete pour occurred on April 5, 2002. The first E ring tenants returned to the newly restored section on August 15, 2002, and complete restoration of W1 ring E between Corridors 4 and 5 was finished by September 11, 2002 [Goldberg et al. 2002; Vogel 2007]. The last tenants to reoccupy Wedge 1 of the Pentagon did so on February 6, 2003 [Pentagon Memorial Fund 2011].

Figure 2 provides a timeline of significant events the Pentagon after the crash of American Airlines Flight 77 covering the initial response to the reoccupancy of the affected areas by Pentagon employees. Figure 3 provides with greater detail a timeline of significant events at the Pentagon covering the response phase through demolition and cleanup.

American Red Cross and Salvation Army personnel provided food and water to responders and assisted in providing mental health services to responders, families of victims, military, and others [American Red Cross 2006; Condon-Rall 2011; Salvation Army 2011].

Appendix B provides a list of responding agencies, departments, organizations, and volunteers to the Pentagon based upon the literature search used for this report.

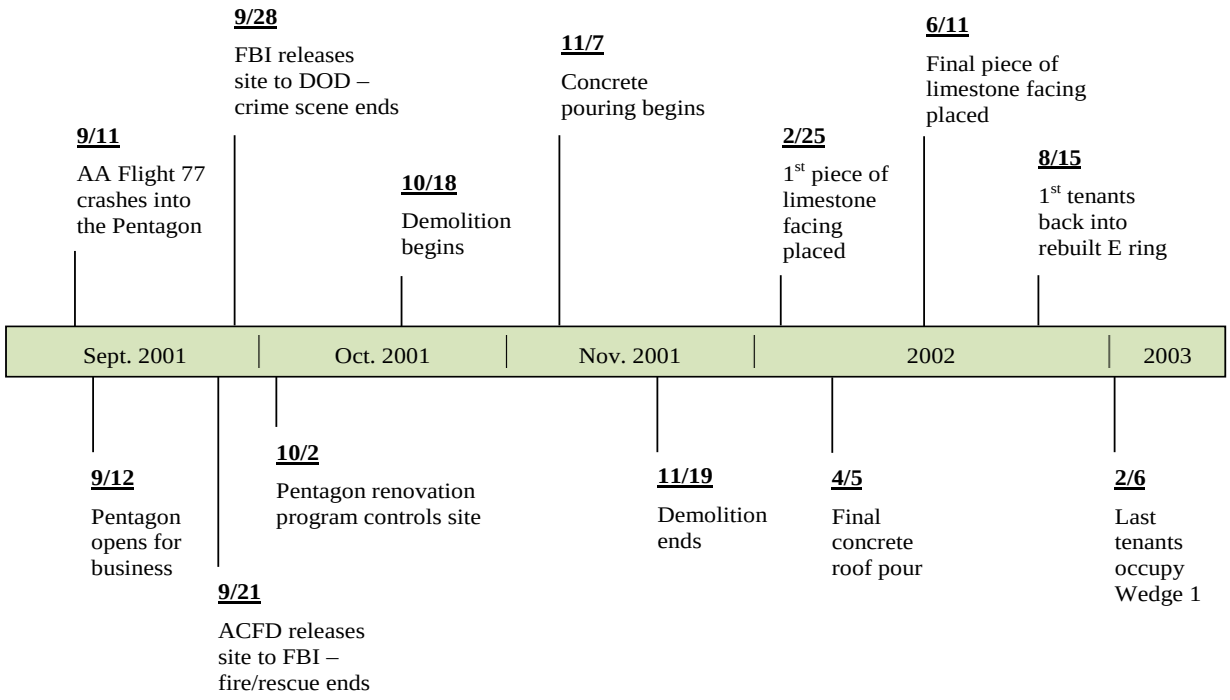

Figure 2. Timeline of Significant Events at the Pentagon – Initial Response to Reoccupancy

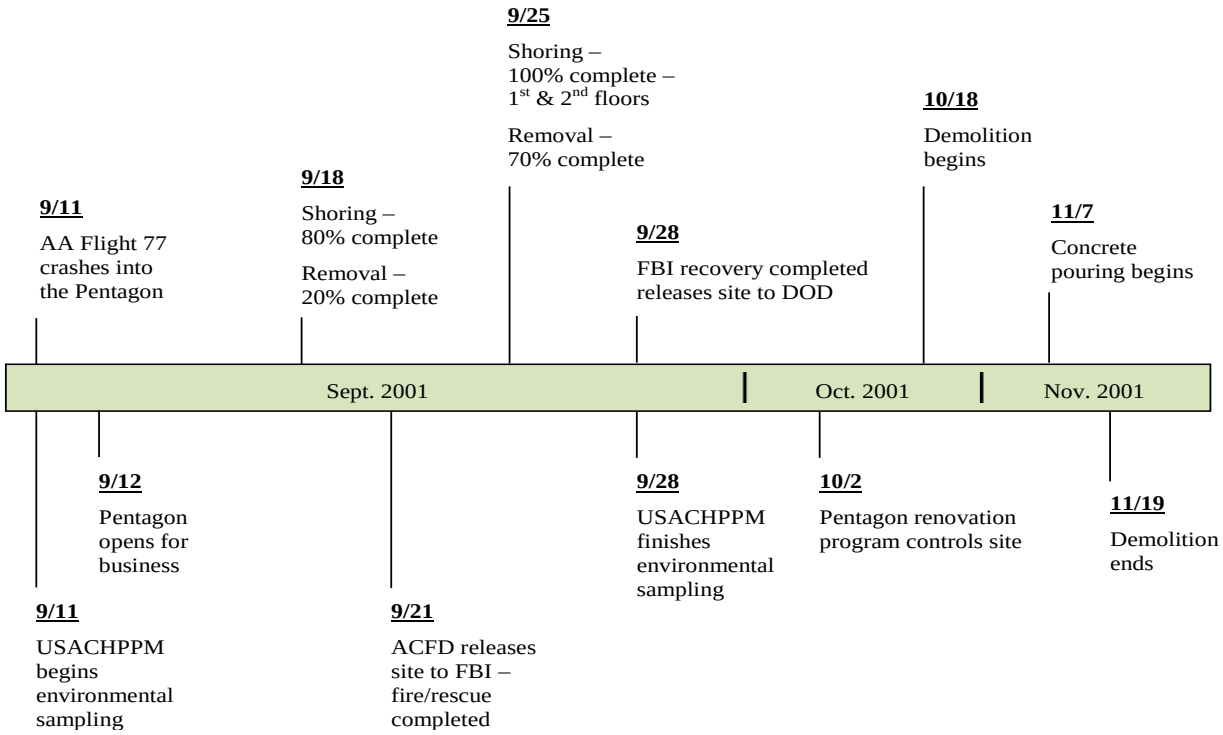

Figure 3. Timeline of Significant Events at the Pentagon – Response to Demolition/Cleanup

Recommended Pentagon Site Concluding Date

Although most of the fire department personnel left the site after it was turned over to the FBI on September 21, 2001, fire and police presence continued at the Pentagon until the site was turned over to DOD on September 26, 2001, or September 28, 2001. The literature suggests that after the site was turned over to DOD, many of the services typically provided by police departments were handled onsite by military police or by Defense Protective Service personnel. However, the available information does not indicate what period of time fire or police department personnel were onsite from the end of September until the completion of demolition and cleanup activities on November 19, 2001.

Recovery or cleanup contractors were onsite at the Pentagon until November 19, 2001, which is the date demolition activities concluded.

The available information does not provide a complete listing of all volunteers onsite, or the timeframes of their participation. It is reasonable to conclude that at least some volunteers were onsite through the crime scene phase of the response, ending on September 26, 2001, or 28, 2001. However, the available information does not indicate whether volunteers were onsite during the demolition and cleanup phase of the response.

The available information has substantial uncertainties that limit the ability to determine with absolute precision specific end times for each group's activities at the site. To ensure that those who did respond are provided adequate opportunity for medical monitoring and treatment benefits, WTCHP eligibility is recommended for the period covering September 11, 2001 through November 19, 2001 for individuals who worked for a fire department, a police department, or a recovery or cleanup contractor, or were a volunteer, and performed rescue, recovery, demolition, debris cleanup, or other related services at the Pentagon site of the terrorist-related aircraft crash of September 11, 2001.

Pentagon Site Concluding Date: November 19, 2001

Exposures, Personal Protective Equipment, and Decontamination

Response to the Pentagon included potential exposure to chemical, biological, and physical hazards and stressors as well as safety hazards. Activities inside the affected area of the Pentagon introduced the potential for exposure to jet fuel, smoke, heat from the fire (heat exhaustion and dehydration), and human remains. The extent of damage to the electrical system in combination with the amount of standing water generated from the fire fighting activities made electrocution of responders a possibility [Goldberg et al. 2007]. The rubble from the heavily damaged areas included water, sagging ceilings, electrical wiring, melting plastics,

plumbing, mangled HVAC components, metal, nails, broken glass, wood, plaster, floor tiles, general office furniture and equipment, asbestos, lead paint, black soot, general dust, jet fuel, and human remains [Goldberg et al. 2007]. Fire fighters used saws and other tools to make trench cuts on the roof (taking approximately 30–40 minutes for each concrete cut) to stop the fire from traveling to other areas of the Pentagon [Creed and Newman 2008]. Although the available literature does address other potential hazards, this activity probably created high noise levels and generated concrete dust that may have contained silica. Beneath the concrete layer of the roof, but not in the pitched roof areas above rings A and E, was horsehair insulation[1], a common insulation in the 1940s [Goldberg et al. 2007; Creed and Newman 2008]. In addition to the horsehair insulation, it was reported that there was a layer of waterproof asbestos [Budd 2011] and straw in the roof [Brown 2011]. In addition to the hazards within the Pentagon, there were a number of combustion sources in the areas that were supporting the response. In the first 24-hours of the response, golf carts, heaters, generators, stoves, and other sources consumed 600 gallons of gasoline and diesel fuel; 16,000 gallons of gasoline and diesel fuel were consumed in the first 10 days [Titan Systems Corporation 2002]. These combustion sources release CO, particulate, NO_x, and many other compounds.

Early on in the response to the Pentagon, the leaders within the incident command structure recognized the importance of protecting the responders during their various activities onsite. No personnel were allowed onsite without the designated PPE [FEMA 2004]. The minimum PPE discussed at daily safety meetings was a respirator and Tyvek® suits [Titan Systems Corporation 2002]. Fire fighters used SCBA during entries into the Pentagon, but because of the air limitations of the tank, fire fighters would delay going on air until they felt it was absolutely necessary [Goldberg et al. 2007; Defina et al. 2011]. Replenishing SCBA bottles was also a challenge, as fire departments did not use the same type or model SCBA [Titan Systems Corporation 2002]. While working on the Pentagon roof trying to control the spread of fire (trench cutting and other activities), some fire fighters removed their turnout gear down to their shirt sleeves to cool down from the heat of the fire, during the hottest parts of the day, and because of the high level of work activity [Creed and Newman 2008]. The literature reports do not indicate whether fire fighters used any type of fall protection while working on the roof. Arlington County Police supporting the FBI's evidence recovery operations wore, "latex over-boots, protective overalls, respirators, safety glasses, head covers, and heavy leather gloves worn over latex gloves" [Titan Systems Corporation 2002]. The level of respiratory protection

[1] A number of insulation subject matter experts (SMEs) were contacted to investigate the characteristics of horsehair insulation. Because of its lack of recent use, none were able to provide insight into how the insulation may have been applied, binders that may have been used, or available studies evaluating thermal degradation. As it is an organic, natural substance, compounds formed when heat is applied may include CO, CO2, various nitrogen compounds including hydrogen cyanide, and various sulfur compounds.

was not specified. Jackson et al. [2002] provides insight into PPE and what worked or did not work during the Pentagon response.

The soldiers handling human remains wore PPE to protect themselves against potential biohazards. Soldiers reportedly wore coveralls, rubber boots, safety glasses, hard hats, carbon-filter face masks, and up to three layers of gloves [Goldberg et al. 2007; Creed and Newman 2008].[2] Suits were taped shut at the ankles and wrists, which in addition to the limited breathability of the suit fabric created a very hot environment. Soldiers using goggles reported fogging, and because PPE was in short supply during the initial stages of the response, they shared respirators [Goldberg et al. 2007]. Frequent respirator filter change was the rule as well as going through decontamination [Goldberg et al. 2007]. Those responders sifting through the north parking lot debris pile for human remains hosed down the debris pile to reduce the amount of concrete dust being generated [Goldberg et al. 2007].

The use of cadaver dogs began on September 15, 2001. Dog handlers wore protective suits, gloves, and face masks, but reportedly did not always wear their face mask because of the need to communicate with their dogs [Goldberg et al. 2007]. Entries into the Pentagon with dogs lasted 15–20 minutes as the dogs begin to lose their concentration during longer entries.

The Arlington-based NMRT set up three decontamination corridors for responders exiting the building [Titan Systems Corporation 2002]. Decontamination included scrubbing boots to remove any debris and removal of Tyvek® suits [Creed and Newman 2008]. Equipment used by the USAR teams and fire department TRTs were required to be laundered each night [Titan Systems Corporation 2002]. No other specifics were given on the laundering process or where it took place.

Within a few hours after impact, Pentagon personnel shut down ventilation systems servicing corridors 3, 4, 5, and 6. Air barriers were constructed in corridors 1, 2, 7, and 8 to keep smoke and other contaminants from becoming entrained into the ventilation systems servicing all other areas within the Pentagon [Goldberg et al. 2007]. The Safety and Occupational Health Branch of the WHS had contractors remove water soaked plaster and asbestos that fell from ceilings onto furniture and floors and clean soot and smoke from inhabitable areas of the Pentagon; 50 people began on September 12, 2001, and worked 24 hours per day, 7 days per week for several weeks [Goldberg et al. 2007].

[2] In most cases, specifics on PPE used during the response are not provided in the literature. Written descriptions and photographs suggest that “coveralls” or “suits” refer to Tyvek® suits or other woven materials and “respirators” or other descriptions of respirators refer to filtering facepiece respirators, half-face elastomeric respirators with combination organic vapor/P–100 cartridges, or half-face elastomeric respirators with P–100 filters. The literature does not provide information on respirator fit testing, training, or medical clearance.

Review of Exposures

Environmental Monitoring

The following information was gathered from a non-FOUO USACHPPM report on environmental sampling conducted at the Pentagon and a book published by the Office of the Surgeon General, U.S. Army [USACHPPM 2001; Condon-Rall 2011]. Unless noted otherwise, the following information originated in the USACHPPM document. The Pentagon environmental sampling conducted was by personnel from (1) USACHPPM, SMART-PM; (2) Naval Medical Research Centers, Biological Defense Research Directorate Operations; (3) chemical team from Walter Reed Army Medical Center; (4) Office of Safety and Health, Technical Support Staff, Federal Facilities Division, WHS; (5) The Uniformed Services University of the Health Sciences, Department of Preventive Medicine and Biometrics; (6) U.S. Air Force, and (7) Applied Environmental (a civilian contractor, headquartered in Reston, Virginia). This sampling effort lasted from September 11–28, 2001. USACHPPM chemists analyzed samples from September 12, 2001 to early November 2001 [Condon-Rall 2011].

The main goals of the environmental sampling effort were to determine levels of hazardous contaminants, recommend mitigation strategies for hazards, and measure/assess health impact of contaminants present to building occupants. To accomplish these tasks, the SMART-PM Advanced Team arrived on September 11, 2001, and began conducting area sampling for aldehydes, VOCs, dusts, CO, H_2S, O_2, and combustible gases. The SMART-PM Main Body was onsite on September 12, 2001 and began the process of determining the potential hazards to building occupants and those responders in and around the crash site and effectiveness of cleanup activities. This included area sampling for (1) radiological health hazards (alpha, beta and gamma radiation), respirable dust, VOCs, CO, and CO_2 by directing-reading instruments; (2) air sampling for PAHs, metals, asbestos, VOCs, SVOCs, and total suspended particulates; (3) wipe sampling for asbestos, metals (lead), PCBs, and dioxins, and (4) drinking water within the Pentagon. Environmental sampling results were compared to AGCIH TLVs, NIOSH RELs, and OSHA PELs. The Naval Medical Research Center's Biological Defense Research Directorate Operations conducted sampling for the presence of biological hazards; the presence of *Yersinia pestis*, *Bacillus anthracis*, Orthopoxviruses (including smallpox), botulinum toxin A/B, and *Francisella tularensis*. Tables 1–9 provide all the chemical compounds analyzed for from air, surface, or drinking water samples.

A wide range of sampling methods was used as it was anticipated that many different contaminants could be generated from the burning aircraft, jet fuel, and objects inside the Pentagon offices. Area sampling was conducted on each floor, began at the point closest to the

impact area, and moved away from the impact area through the Pentagon (most contamination to least contamination). Personal sampling was conducted on military personnel and responders participating in search, rescue, recovery, and cleanup activities. These samples focused on lead, silica, asbestos, VOCs, PAHs, benzene, and aldehydes.

Over the course of the response, thousands of air, surface wipe, and water samples were collected. A summary of the air and wipe sampling results (compared to AGCIH TLVs, NIOSH RELs, and OSHA PELs) from locations around the incident site is as follows:

1. All samples collected on floors 1–5 were below relevant health standards, except for lead (< 10%) and asbestos (< 5%) wipes. The majority of lead and asbestos wipes that exceeded the limit were collected on the fourth and fifth floors before cleanup activities.

2. All samples collected in the basement, except for one asbestos wipe, were below relevant health standards.

3. All samples collected in the courtyard were below relevant health standards.

4. All samples collected in the Child Development Center were below relevant health standards.

5. All personal air samples collected at the incident site for lead, asbestos, and silica were below relevant OELs.

6. All personal air samples collected at the military guard locations for formaldehyde, aldehydes, PAHs, and VOCs were below relevant OELs and most below their analytical limits of detection.

7. The radiological assessment of the site indicated that no radiological hazard was associated with this event.

8. The biological warfare agent assessment of the site indicated that no biological warfare hazard was associated with this event.

9. The chemical warfare agent assessment of the site indicated that no chemical warfare hazard was associated with this event.

10. The drinking water assessment of the site indicated that the water was safe and did not pose a health hazard. One particular tank that was offline at the time of the survey did contain elevated levels of ammonia. It was recommended that this tank be flushed and disinfected before being brought back online.

11. Soldiers who were screened for blood-lead levels showed results similar to the average blood-lead level in adults without occupational exposure to lead as measured by CDC in the latest National Health and Nutrition Examination Survey.

Further information on environmental wipe sampling results and analysis from the sampling described above can be found in Gaborek et al. [2001].

The following information was gathered from Condon-Rall [2011]. EPA led sampling efforts of its own and other state and federal agencies from September 11–29, 2001. Environmental samples were collected from the air, water, and debris from around the areas around recovery workers, Pentagon perimeter, and areas in and around Washington DC. Except for one bulk sample that contained over 1% of asbestos, all other air, wipe, and bulk samples were below regulatory limits for asbestos, silica, lead, and VOCs. EPA concluded that the Pentagon fire did not affect the environment outside the Pentagon. This was confirmed by the Virginia Department of Environmental Quality whose air monitors did not show anything more than the typical low-level pollution. High metal content was found from debris and ash samples collected inside the building, but EPA indicated that it was not of concern because of the short-term exposure and limited contact routes. Before activities occurred in certain areas, FBI and ACFD personnel used four-gas meters and photoionization detectors to monitor areas for CO, H_2S, VOCs, oxygen content, and lower explosive limit.

Goldberg et al. [2007] also reported on environmental sampling efforts including (1) the Pentagon-staffed industrial hygienist monitored for common gases (gases were not specified); (2) ACFD personnel tested for CO in the NMCC; (3) EPA collected water, air, and debris samples and monitored conditions for first responders, occupants, and community; (4) OSHA assisted with asbestos and structural issues; and (5) NMRT personnel conducted tests for biological, chemical, and radiation exposures.

Starting in the 1970s through the 1990s, the DOT FAA Civil Aeromedical Institute conducted a number of inhalation toxicology studies that provide insight into products of combustion from aircraft materials (e.g., fabrics, foams, insulation, liners, cabin panels, and panel components) and fluids (engine oil, hydraulic fluid, mineral oil). Many of the studies focus on CO and HCN, although some studies discuss hydrogen chloride, acrolein, sulfur dioxide, and benzene.

Chaturvedi and Sanders [1995] and Chaturvedi [2010] provide informative discussions on various factors of a fire that can produce diverse combustion products from the same and differing materials. Hartzell [1996] discusses combustion toxicology and describes some components of smoke: CO, CO_2, hydrogen cyanide, halogen acids (hydrogen fluoride, hydrogen chloride, and hydrogen bromide), and organic irritants. Two U.S. Air Force documents provide some information on combustion products coming from composite materials found in military aircraft [Costantino et al. 2001a,b].

Appendix D provides references to follow-up studies on search and rescue dogs and their handlers who deployed to the WTC, Fresh Kills landfill (area used to sort through WTC debris), and the Pentagon. These studies conducted medical and behavioral surveillance, or looked at morbidity or pathology and toxicology findings.

Biological Monitoring

During the response, blood-lead levels were drawn on approximately 85 military members responding at the Pentagon by performing guard duties in the contaminated/blocked off areas because they had the potential for high exposure due to their proximity to the crash site. A target blood lead of 10 micrograms per deciliter was selected as this is the protective limit for pregnant or breastfeeding women and the most conservative level. The blood lead measured ranged from 1–6 micrograms per deciliter with the majority of measurements between 1 microgram per deciliter and 3 micrograms per deciliter [USACHPPM 2001; Condon-Rall 2011].

Mental Health

"Operation Solace" was a collaborative effort between civilian and military (Army, Navy, Air Force) entities to address the mental health of "injured survivors, family members of victims, Pentagon employees, search and rescue workers, recovery personnel, family assistance center staffs, casualty assistance officers, body handlers, and others" from mid-October to December; the Army continued with long-term assistance after December [Condon-Rall 2011]. Although not officially listed within Operation Solace, "military chaplains not associated with the SMART-SM team, fire department chaplains, Red Cross mental health professionals, Salvation Army personnel, Veterans Affairs psychiatric specialists, church volunteers, massage therapists, chiropractors, and even therapy dogs," assisted in this effort [Condon-Rall 2011]. Soon after the incident, personnel from the DiLorenzo Tricare Health Clinic, military chaplains, the DeWitt Army Community Hospital in Fort Belvoir, Virginia, and ACFD mental health teams were onsite [Condon-Rall 2011]. The North Atlantic Regional Command, SMART-SM team was activated and eventually consisted of almost 100 mental health professionals working in and around the Pentagon [Condon-Rall 2011]. A part of the SMART-SM team spent quite a bit of time supporting those military personnel actively engaged in the search and removal of human

remains from the incident site [Condon-Rall 2011]. Mental health professionals were also onsite at the Dover AFB mortuary to provide assistance to those personnel handling human remains [Condon-Rall 2011].

The PFAC was operating on September 12, 2001 out of the Crystal City Sheraton Hotel and assisted affected family members. The PFAC was the headquarters for DOD, the airlines, federal agencies, and relief organizations [Goldberg et al. 2007]. The center remained open 24-hours a day and provided family members numerous services. Although the PFAC discontinued operations at the Sheraton on October 12, 2001, family support continued through other means [Goldberg et al. 2007].

USACHPPM initiated and collaborated with other entities to develop and implement the Pentagon Post Disaster Health Assessment survey for service members and civilian employees within the Pentagon [Wells 2002; Condon-Rall 2011]. This survey gathered information on injuries, illnesses, and exposures and included a mental health component. The survey was deployed on October 15, 2001, and closed on January 16, 2002. This survey was provided to over 19,000 Pentagon employees with greater than 4,000 responding. Briefly, the survey indicated that many of the responding employees were at or near the Pentagon at the time of the incident, many were exposed to environmental contaminants, and few respondents were trapped or injured [Wells 2002]. The mental health portion of the survey indicated that respondents reported issues such as alcohol abuse, posttraumatic stress disorder, and depression among other symptoms [Hoge 2002a,b; Jordan et al. 2004; Condon-Rall 2011].

Creed and Newman [2008] reported that 15 fire fighters left ACFD for reasons related to posttraumatic stress disorder and others were treated for PTSD, but stayed with ACFD. Robbers and Jenkins [2005] concluded that PTSD was found among officers in the ACFD and further research is warranted. Simons et al. [2005], Elhai et al. [2006], Gaher et al. [2006], and Long et al. [2007] describe studies of Red Cross workers at the Pentagon and Shanksville, Pennsylvania sites where they looked at the use of mental health services before and after responses, PTSD, and alcohol usage.

In October 1992, an El Al Boeing 747 cargo aircraft crashed into a suburb of Amsterdam, The Netherlands killing 43 people. Donker et al. 2002; Slottje et al. 2005a,b, 2006, 2007, 2008a,b; Huizink 2006a; Page and Wessely 2006; and Witteveen et al. 2007 provide insight into the health effects (e.g., long-term health complaints, use of health care and drugs, autoimmune health effects, perceived health-related quality of life, psychological distress) of fire fighters, police officers, and other disaster assistance workers who responded to the incident. The studies conclude that compared with their non-responding counterparts, responders reported

(1) more physical and mental health complaints; (2) a lower quality of life after the incident; (3) more autoimmune symptoms; (4) more self-medication (instead of prescribed use), and use of sleeping pills or tranquilizers; and/or (5) more use of health care.

Appendix E provides references to additional studies looking at PTSD, alcohol use, depression, perceived safety after the event, and mental health effects of Pentagon employees months and years after the Pentagon incident. This appendix provides references to documents written by the various civilian and military entities describing their efforts in providing mental health support services to responders, Pentagon employees, mortuary workers, family members, Red Cross workers, and others.

Appendix F provides references to additional Pentagon or Shanksville studies or documents providing (1) both exposure and mental health information, (2) civilian and military entities response efforts at the Pentagon or Shanksville sites, (3) a general synopsis of the Pentagon or Shanksville incidents, or (4) general “lessons learned.”

Shanksville, Pennsylvania, Response

Background

The area of the crash site was a reclaimed coal strip mine owned by Svonavec Coal Company. The area was mined by the Diamond T Coal Company in the 1960's and then backfilled and planted over. The crash site was mined again in the late 1980s by PBS Coal, who then reclaimed the land in 1994. The strip cut mining process involves removing the soil down to the coal, removing the coal, replacing removed soil, and planting over the area. The location of the crash site had been mined to a depth of around 115 feet. In the background of the site was a forested area with a number of privately owned cabins.

Impact

United Airlines Flight 93 crashed in Stonycreek Township, Somerset County, Pennsylvania, killing all 44 people onboard at 10:03 a.m. on September 11, 2001. Flight 93 was a Boeing 757, 155 feet long by 125 feet wide. At impact, the airliner was traveling over 550 mph with approximately 7,000 gallons of jet fuel [NPS 2011]. The airliner struck the ground almost upside down at a 40-degree angle and created a crater roughly 15 feet deep and 30 feet across [National Commission on Terrorist Attacks Upon the United States 2004].

Response

The impact did not result in many large pieces of airline debris, thereby limiting the need for large scale fire fighting. Fire fighters onsite used Indian pumps (a 5-gallon, hand-pumped tank or bladder) to extinguish hot spots and brush fires [Kashurba 2002]. Ten volunteer fire departments responded [TriData Corporation 2002].[3] Passenger rescue operations were not implemented, as it was clear that no one survived. Shortly after arriving on-site, the FBI assumed control and brought in more than 150 agents and support personnel to assist in the investigation. Approximately 600 Pennsylvania State Troopers provided security in and around the site. The Somerset emergency management agency supervised establishing a working city around the site – mobile command centers, incident management trailers, etc. [Kashurba 2002].

During the evidence and human remains recovery period, the crater was excavated to an area roughly 85 feet by 85 feet and a depth of about 40 feet [NPS 2011]. The investigators grid the entire site, sifted through the soil, recovered and cataloged personal human remains, personal effects, and airplane debris, and returned the soil to the crater [Kashurba 2002; NPS 2011]. A local Pennsylvania National Guard Armory was used as the morgue. It is estimated that by

[3] In this document, the National Volunteer Fire Council provides information on the volunteer fire departments that responded, the number of fire fighters that responded, and how they responded (onsite, backfill, both).

September 14, 2001, the site had more than 400 volunteers assisting in the on-site activities and about 150 disaster mortuary operational response team personnel working with human remains [Grant et al. 2003]. The DMORT response ended on September 25, 2001 [Sledzik 2002]. When human remains could not be identified, they were sent to the Armed Forces Institute of Pathology in Rockville, Maryland [Lash 2001]. The final victim identification occurred on December 19, 2001 [Levin 2001]. After 13 days of work onsite, the FBI relinquished control of the site to the Somerset County Coroner on September 24, 2001. Approximately 74 agencies and more than 1000 responders and volunteers assisted in the onsite activities [Grant et al. 2003]. During the last weekend of September 2001, the Somerset County coroner enlisted the assistance of approximately 300 personnel from the Pennsylvania Region 13 Counter-terrorism Task Force (task force of 13 counties in western Pennsylvania), the State Funeral Directors Association, and other volunteers to conduct "Operation Clean Sweep," which involved scouring the area to pick up remaining plane parts and flagging any human remains or objects resembling human remains [Kashurba 2002; Grant et al. 2003].

After the response to the crash, pertinent parties discussed with ERM (contracted by United Airlines to reclaim the site) about how to reclaim the crash site. In accordance with the Pennsylvania Department of Environmental Protection, ERM collected core samples for jet fuel, collected water samples from a pond near the site, and backfilled the crater from October 1, 2001 to October 3, 2001. Because remains and plane debris could have been imbedded within trees nearby, many trees surrounding the site were cut down and buried in the crater. The site was restored as much as possible to the original appearance; 4–6 inches of topsoil was added on top of the crater and throughout the forested area, and the area was seeded with flowers and grasses.

The Somerset County coroner indicated that in the years following the response, members of the Pennsylvania National Guard and Camp Cadet (camp for youth operated by the Pennsylvania State Police) had been out to the site to collect aircraft parts [Daily American 2005; Miller 2011]. Available information indicates that law enforcement personnel remained at the site to provide security for a number of years [Daily American 2005]. The Somerset County coroner officially released the site to the respective landowners in August 2005 [Daily American 2005]. The National Park Service purchased much of the land around the site is overseeing the construction of a memorial to Flight 93 [NPS 2011].

Figure 4 provides a timeline of significant events after the crash of United Airlines Flight 93 covering the initial response, land restoration, and release of the Shanksville site.

During the Shanksville response, the Red Cross, and the Salvation Army assumed the role of feeding the responders, and providing mental health services, among other efforts [Kashurba 2002; American Red Cross 2006; Salvation Army 2011]. The Red Cross had more than 300 volunteers and 29 paid staff to assist in the effort, and 30 local clergy members volunteered their time [Kashurba 2002]. Red Cross personnel staged at the scene, at operations headquarters, the morgue, and with the families of victims [American Red Cross 2010].

Appendix C provides a list of responding agencies, departments, organizations, and volunteers to Shanksville based upon the literature search used for this report.

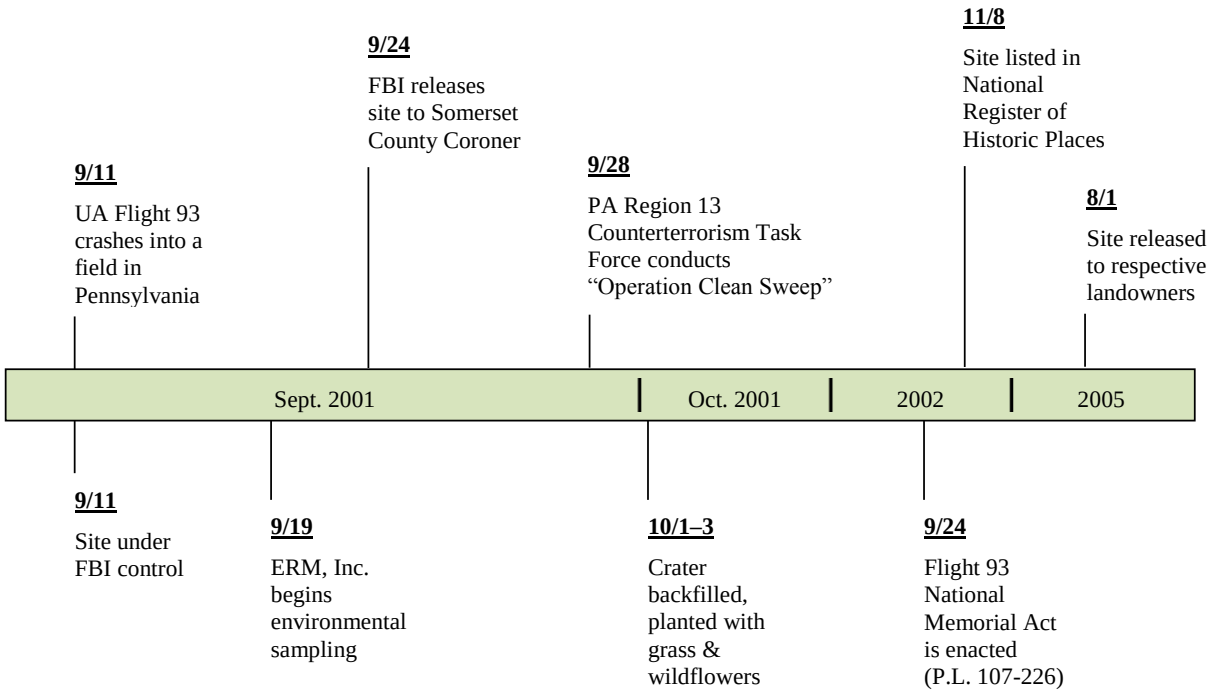

Figure 4. Timeline of Significant Events at Shanksville – Initial Response to Site Release

Recommended Shanksville, Pennsylvania Site Concluding Date

Most of the fire and police department personnel and volunteers left the site after the FBI turned the site over to the Somerset County coroner on September 24, 2001. However, fire and police department and volunteer presence was limited at the Shanksville site until the conclusion of the final sweep of the crash site for aircraft parts and potential human remains on September 29–30, 2001. Available information suggests that law enforcement personnel remained at the site to provide security for a number of years. The available information does

not indicate whether fire department personnel or volunteers were onsite during the site restoration activities from October 1–3, 2001.

Available information indicates that environmental restoration contractors restored the site close to its original appearance from October 1–3, 2001, signaling the conclusion of the response.

The available information has substantial uncertainties that limit the ability to determine with absolute precision specific end times for each group's activities at the site. To ensure that those who did respond are provided adequate opportunity for medical monitoring and treatment benefits, WTCHP eligibility is recommended for the period covering September 11, 2001 to October 3, 2001 for individuals who worked for a fire department, police department, or a recovery or cleanup contractor, or were a volunteer, and performed rescue, recovery, demolition, debris cleanup, or other related services at the Shanksville site of the terrorist-related aircraft crash of September 11, 2001.

Shanksville, Pennsylvania Site Concluding Date: October 3, 2001

Exposures, Personal Protective Equipment, and Decontamination

An onsite fire department chief reported [Clark 2011] that the PPE worn by responders included the following: a Kappler® Disposal suit with hood worn over coveralls, booties worn over rubber boots, safety glasses, and respirators (disposable dust mask).[4] The decontamination process took place in the warm zone and consisted of a four-step process (two scrubs and two rinses from arm level to the foot level) for all who entered the designated hot zone [Clark 2011]. A "germicidal liquid" was used for decontamination, because of the potential for bloodborne pathogen exposure from contact with human remains [Clark 2011]. Decontamination did not begin until the federal representatives were ready to start working in the impact area; only federal workers and some excavating contractors were in that area [Clark 2011]. Medical surveillance personnel were also onsite [Clark 2011]. PPE, decontamination, and medical surveillance were coordinated with the federal agencies and all special teams involved in the response [Clark 2011].

Kashurba [2002] writes that decontamination was conducted on all personnel who entered the site. Responders wore rubber gloves, Tyvek® suits, and shoe covers. The decontamination line consisted of a wash station, dumpsters, and a blue decontamination tent that held four small swimming pools. The pools were positioned in two rows of two; responders walked through the

[4] Detailed information on respirators and other PPE used in the Shanksville response is not provided in the literature reviewed and cited in this document.

first pool and then scrubbed their shoes (chlorinated water). They then walked through the next pool, which contained more soap and water plus chlorine. They were rinsed, then took off their suits, removed their respirators, and finished at a station for washing their hands, face, and respirator.

Review of Exposures

Environmental Monitoring

The available literature and informal NIOSH-led responder interviews did not identify any monitoring data to document personal exposures among those responding to the Shanksville crash. It should be noted that this response was very different from the World Trade Center and Pentagon responses as the only debris originated from Flight 93 and the groundcover in the area; no building debris was involved. Exposures were limited to residual jet fuel and hydraulic fluids, emissions from a few small-scale fires or smoldering debris, human remains, and potential hazards created during the response (CO, diesel exhaust, noise, etc.). However, during the response and reclamation of the site, environmental monitoring (soil and water) was conducted as required under Pennsylvania law. Although it is not appropriate to link the results from this report to responder exposures, the results provide insight into potential chemical exposures.

Environmental Resources Management, Inc. was contracted on behalf of United Airlines to document soil and water quality at the site. Site characterization was conducted according to the PADEP and the Pennsylvania Land Recycling and Environmental Remediation Standards Act (Act 2) [PALRB 1995]. ERM issued a final report describing the site history, and the sampling plan, methodology, and results of environmental sampling. The following narrative summarizes the findings of the ERM final report [ERM 2002].

ERM reviewed the flight manifests to determine whether any hazardous materials were on board other than jet fuel and hydraulic fluid. The manifests did not indicate any cargo that could have contained potential sources of contamination. In their report, ERM provided a jet fuel risk assessment report (Jet A fuel) describing the individual compounds found within this particular fuel by analyzing an unweathered sample from the Denver International Airport. According to the report, the American Petroleum Institute and the aviation industry consider this a representative sample of this particular type of fuel. The analysis indicated that Jet A fuel is made up of carbon compounds in the C_8–C_{17} range: 83% (normalized) is cycloparaffins, n-paraffins, and branched paraffins and 17% is aromatics. Approximately 194 compounds were identified. The analysis determined that the Jet A fuel sample consisted of 0.0063% benzene, 0.063% toluene, 0.067% ethylbenzene, and 0.25% xylenes. This type of fuel is designed to

consist of very small amounts of PAHs, which was confirmed by ERM in their analysis. Weathering of this type of fuel will reduce the concentrations of these compounds. See Appendix A for more information on Jet A fuel.

On the basis of jet fuel analysis results and for the purpose of site characterization, ERM used the PADEP list of COPC to identify the compounds for soil analysis: benzene, toluene, ethyl benzene, total xylenes, cumene, naphthalene, 1,2-dibromomethane, 1,2-dichloroethane, and total lead. Results were compared to the COPC MSC Direct Contact Standards or Soil to Ground Water Standards. Total lead is not associated with Jet A fuel, so it was not used in the characterization of the site.

The ERM report indicated that all site work under the provisions of the OSHA Bloodborne Pathogens Standard [29 CFR 1910.1030] as the potential for exposure to biological hazards was recognized and PPE worn. However, the report does not detail what PPE was worn, nor whether all responders onsite or specifically ERM personnel followed these precautions. The ERM report does not provide further details.

Soil samples were collected from mid-September to mid-October 2001. Soil was collected from the bottom of the excavated crater, crater backfill material, surface, subsurface, and subsurface background. Soil samples were analyzed by a portable field gas chromatograph or sent to a laboratory for analysis for one or more of the following: TPH, TCL VOCs, TCL SVOCs, DRO, GRO, metals, PCBs, and wet chemistry. Surface and subsurface samples were collected based on a grid system of the site, extending 200 feet to the east, west, and south of the crater and 150 feet to the north. Only lead was found at the bottom of the crater and was attributed to previous mining activities onsite. Of the 177 surface samples analyzed for TPH, 45 showed detectable concentrations ranging from 2.8–310 mg/kg (> 1,000 mg/kg TPH required further analysis). The report is unclear as to the number of subsurface samples collected. The report concludes that no surface or subsurface soil samples exceeded any Pennsylvania standards.

Five groundwater monitoring wells were installed in early October 2001 and in February 2002. Monitoring was conducted to determine if the Jet A fuel COPCs were in the groundwater. Four rounds of groundwater sampling revealed one sample detecting benzene; the result did not exceed the Pennsylvania standards. Additional water samples were collected from ponds near the site. Results indicated concentration of metals, but no TCL VOCs, TCL SVOCs, or PCBs were detected above the practical quantification limits.

Backgound soil samples were collected to evaluate the existing concentrations of VOCs and SVOCs at the site. Several polynuclear aromatic compounds as well as xylene were detected in

the soil boring samples. The report indicated that the previous mining operations at the site could contribute to the polynuclear aromatic concentrations as Jet A fuel contributes very little. No compounds found exceeded any Pennsylvania standards.

The report concludes in its executive summary that the surface soils, subsurface soils, and ground water beneath the site did not exceed any of the PADEP statewide health standards and did not require any remediation. None of the surface water results indicated any contamination that could be attributed to the Flight 93 crash.

The ERM sampling results did not reveal many compounds over the detection limit. However, most of these samples were collected weeks after the response. It is likely that chemical components in Jet A fuel existed in the early stages of the response and were a possible exposure to responders. Fire fighters did report the smell of jet fuel early on in the response [Kashurba 2002] though no exposure monitoring data is available to quantify potential worker exposures.

For additional information on potentially relevant exposure and mental health information for Shanksville responders, see the Pentagon section of this report.

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Tables

Table 1. Air sampling using direct reading instruments at the Pentagon

Compound	Method
Carbon monoxide	Varies
Formaldehyde	Varies
Hydrogen sulfide	Varies
LEL	Varies
PID	Varies
Oxygen	Varies
Respirable dust	Varies
VOCs	Varies

Table 2. Air sampling for aldehydes at the Pentagon

Compound	Method
Acetaldehyde	Varies
Acrolein	Varies
Butyraldehyde	Varies
Crotonaldehyde	Varies
Formaldehyde	Varies
Hexaldehyde	Varies
Isobutyraldehyde	Varies
Isovaleraldehyde	Varies
n-Heptyl	Varies
n-Valeraldehyde	Varies
Propionaldehyde	Varies

Table 3. Air sampling for asbestos at the Pentagon

Compound	Method
Cellulose Fibers	EPA 600.0/R93/116
Chrysotile Asbestos	EPA 600.0/R93/116
Cotton Fibers	EPA 600.0/R93/116
Fiber Glass	EPA 600.0/R93/116
Mineral Wool	EPA 600.0/R93/116
No asbestos found	EPA 600.0/R93/116
Non-asbestos Fibers	EPA 600.0/R93/116
Non-fibrous Material	EPA 600.0/R93/116
Synthetic Fibers	EPA 600.0/R93/116

Table 4. Air sampling for BTEX at the Pentagon

Compound	Method
Benzene	NIOSH 1501
Ethylbenzene	NIOSH 1501
Naphthalene	NIOSH 1501
Styrene	NIOSH 1501
Toluene	NIOSH 1501
Xylenes	NIOSH 1501

Table 5. Air and wipe sampling for metals at the Pentagon

Compound	Method
Nickel	MOD NIOSH 7300 MET51, EPA 200.8 MET21
Lead (air)	MOD NIOSH 7300 MET51, EPA 200.8 MET21
Lead (wipe)	SW-846/EPA 6010B, EPA 6020 MET9, MOD NIOSH 7300 MET51
Beryllium	MOD NIOSH 7300 MET51, EPA 200.8 MET21
Cadmium	MOD NIOSH 7300 MET51, EPA 200.8 MET21
Copper	MOD NIOSH 7300 MET51
Strontium	Varies
Zinc	MOD NIOSH 7300 MET51, EPA 200.8 MET21
Chromium	MOD NIOSH 7300 MET51, EPA 200.8
Manganese	EPA 200.8 MET21
Antimony	EPA 200.8 MET21
Arsenic	EPA 200.8 MET21
Vanadium	EPA 200.8 MET21

Table 6. Air sampling for PAHs at the Pentagon

Compound	Method
Acenaphthene	NIOSH 5506/5515
Acenaphthylene	NIOSH 5506/5515
Anthracene	NIOSH 5506/5515
Benzo(a)anthracene	NIOSH 5506/5515
Benzo(a)pyrene	NIOSH 5506/5515
Benzo(b)fluoroanthene	NIOSH 5506/5515
Benzo(g,h,i)perylene	NIOSH 5506/5515
Benzo(k)fluoroanthene	NIOSH 5506/5515
Chrysene	NIOSH 5506/5515
Dibenz(a,h)anthracene	NIOSH 5506/5515
Fluoranthene	NIOSH 5506/5515
Fluorene	NIOSH 5506/5515
Indeno(1,2,3-cd)pyrene	NIOSH 5506/5515
Naphthalene	NIOSH 5506/5515
Phenanthrene	NIOSH 5506/5515
Pyrene	NIOSH 5506/5515

Table 7. Air sampling for silica at the Pentagon

Compound	Method
Cristobalite	NIOSH 7500, 4th Edition
Quartz (SiO2)	NIOSH 7500, 4th Edition
Silica (as SiO2)	NIOSH 7500, 4th Edition
Tridymite	NIOSH 7500, 4th Edition

Table 8. Drinking water sampling at the Pentagon – regulated and unregulated inorganics, radionuclides, regulated and unregulated VOCs, regulated and unregulated pesticides and SOCs

Compound	Method	Compound	Method
1,1,1,2-Tetrachloroethane	EPA 524.2	Aluminum	EPA 200.7
1,1,2,2-Tetrachloroethane	EPA 524.2	Ammonia	EPA 350.2
1,1,2-Trichloroethane	EPA 524.2	Anthracene	EPA 525.2
1,1-Dichloroethane	EPA 524.2	Antimony	EPA 200.8 MET21
1,1-Dichloroethene	EPA 524.2	Aroclor-1016, 1221, 1232, 1242, 1248, 1254, 1260	EPA 508
1,1-Dichloropropene	EPA 524.2	Arsenic	EPA 200.8 MET21
1,2,3-Trichlorobenzene	EPA 524.2	Atrazine	EPA 507, 525.2
1,2,3-Trichloropropane	EPA 504, 524.2	Barium	EPA 200.8 MET21
1,2,4-Trichlorobenzene	EPA 524.2	Baygon (Propoxur)	EPA 531.1
1,2,4-Trimethylbenzene	EPA 524.2	Benzene	EPA 524.2
1,2-Dibromo-3-chloropropane	EPA 504, 524.2	Benzo(a)anthracene	EPA 525.2
1,2-Dibromoethane	EPA 504, 524.2	Benzo(a)pyrene	EPA 525.2
1,2-Dichlorobenzene	EPA 524.2	Benzo(b)fluoroanthene	EPA 525.2
1,2-Dichloroethane	EPA 524.2	Benzo(g,h,i)perylene	EPA 525.2
1,2-Dichloropropane	EPA 524.2	Benzo(k)fluoroanthene	EPA 525.2
1,3,5-Trimethyl Benzene	EPA 524.2	Beryllium	EPA 200.8 MET21
1,3-Dichlorobenzene	EPA 524.2	Beta Counting Uncertainty	AB001
1,3-Dichloropropane	EPA 524.2	Beta Min. Detectable Conc.	AB001
1,4-Dichlorobenzene	EPA 524.2	Beta Sample Activity	AB001
2,2',3,3'4,5',6,6'-Octachlorob	EPA 525.2	beta-BHC	EPA 508
2,2',3'4,6-Pentachlorobiphenyl	EPA 525.2	bis(2-ethylhexyl)phthalate	EPA 525.2
2,2'4,4'5,6'Hexachlorobiphenyl	EPA 525.2	Bromacil	EPA 507
2,2'4,4'-Tetrachlorobiphenyl	EPA 525.2	Bromobenzene	EPA 524.2
2,2-Dichloropropane	EPA 524.2	Bromochloromethane	EPA 524.2
2,3-Dichlorobiphenyl	EPA 525.2	Bromodichloromethane	EPA 524.2
2,4,5-T	EPA 515.1	Bromoform	EPA 524.2
2,4,5-TP	EPA 515.1	Bromomethane	EPA 524.2
2,4,5-Trichlorobiphenyl	EPA 525.2	Butachlor	EPA 507
2,4-D	EPA 515.1	Butylbenzylphthalate	EPA 525.2
2,4-DB	EPA 515.1	Cadmium	EPA 200.8, MET21
2-Chlorobiphenyl	EPA 525.2	Calcium	EPA 200.7, MET41
2-Chlorotoluene	EPA 524.2	Carbaryl (Sevin)	EPA 531.1
3-Hydroxycarbofuran	EPA 531.1	Carbofuran	EPA 531.1
4-Chlorotoluene	EPA 524.2	Carbon Tetrachloride	EPA 524.2
4-Isopropyltoluene	EPA 524.2	Chlordane, Technical	EPA 508
Acenaphthylene	EPA 525.2	Chloride	EPA 300
Acifluorfen	EPA 515.1	Chlorobenzene	EPA 524.2
Alachlor	EPA 507, 525.2	Chlorobenzilate	EPA 508
Aldicarb	EPA 531.1	Chloroethane	EPA 524.2
Aldicarbsulfone	EPA 531.1	Chloroform	EPA 524.2
Aldicarbsulfoxide	EPA 531.1	Chloromethane	EPA 524.2
Aldrin	EPA 508, 525.2	Chloroneb	EPA 508
Alkalinity, Total	SM 2320	Chlorothalonil	EPA 508
Alpha Counting Uncertainty	AB001	Chlorpyrifos	EPA 507
Alpha Min. Detectable Conc.	AB001	Chromium	EPA 200.8, MET21
Alpha Sample Activity	AB001	Chrysene	EPA 525.2
alpha-BHC	EPA 508	cis-1,2-Dichloroethene	EPA 524.2
alpha-Chlordane	EPA 508	cis-1,3-Dichloropropene	EPA 524.2

Table 8, continued. Drinking water sampling at the Pentagon – regulated and unregulated inorganics, radionuclides, regulated and unregulated VOCs, regulated and unregulated pesticides and SOCs

Compound	Method	Compound	Method
Copper	EPA 200.8, MET21	Methylene Chloride	EPA 524.2
Dalapon	EPA 515.1	Metolachlor	EPA 507
delta-BHC	EPA 508	Metribuzin	EPA 507
Di(2-ethylhexyl)adipate	EPA 525.2	Mirex	EPA 508
Diazinon	EPA 507	Naphthalene	EPA 524.2
Dibenz(a,h)anthracene	EPA 525.2	n-Butylbenzene	EPA 524.2
Dibromochloromethane	EPA 524.2	Nickel	EPA 200.8 MET21
Dibromomethane	EPA 524.2	Nitrite/Nitrate-N	EPA 300
Dicamba	EPA 515.1	n-Propylbenzene	EPA 524.2
Dichlorodifluoromethane	EPA 524.2	Oxamyl	EPA 531.1
Dichloroprop	EPA 515.1	o-Xylene	EPA 524.2
Dieldrin	EPA 508	p,p'-DDD	EPA 508
Diethylphthalate	EPA 525.2	p,p'-DDE	EPA 508
Dimethylphthalate	EPA 525.2	p,p'-DDT	EPA 508
Di-n-butylphthalate	EPA 525.2	Paraquat	EPA 549.1
Dinoseb	EPA 515.1	Parathion	EPA 507
Diquatdibromidemonohydrate	EPA 549.1	Pentachlorophenol	EPA 515.1, 525.2
Endosulfan I	EPA 508	Permethrin, cis-	EPA 508
Endosulfan IIEPA	EPA 508	Permethrin, trans-	EPA 508
Endosulfansulfate	EPA 508	Phenanthrene	EPA 525.2
Endothall	EPA 548.1	Phosphate-P	SM 4500-P,B,E(5)
Endrin	EPA 508, 525.2	Picloram	EPA 515.1
Endrinaldehyde	EPA 508	Prometon	EPA 507
Ethylbenzene	EPA 524.2	Propachlor	EPA 508
Etridiazole	EPA 508	Propazine	EPA 507
Fluorene	EPA 525.2	Pyrene	EPA 525.2
Fluoride	EPA 300	sec-Butylbenzene	EPA 524.2
gamma-BHC (Lindane)	EPA 508, 525.2	Selenium	EPA 200.8 MET21
gamma-Chlordane	EPA 508, 525.2	Silver	EPA 200.8 MET21
Glyphosate	EPA 547	Simazine	EPA 507, 525.2
Heptachlor	EPA 508, 525.2	Sodium	EPA 200.7 MET41
Heptachlorepoxide	EPA 508, 525.2	Styrene	EPA 524.2
Hexachlorobenzene	EPA 508, 525.2	Sulfate	EPA 300
Hexachlorobutadiene	EPA 524.2	Surfactants	EPA 425.1
Hexachlorocyclopentadiene	EPA	tert-Butylbenzene	EPA 524.2
Indeno(1,2,3-cd)pyrene	EPA 525.2	Tetrachloroethylene	EPA 524.2
Iron	EPA 200.7 MET41	Thallium	EPA 200.8 MET21
Isopropylbenzene	EPA 524.2	TOC	EPA 415.1
Lead	EPA 200.8 MET21	Toluene	EPA 524.2
m/p-Xylene	EPA 524.2	Total Dissolved Solids	EPA 160.1
Magnesium	EPA 200.7	Toxaphene	EPA 508
Malathion	EPA 507	trans-1,2-Dichloroethene	EPA 524.2
Manganese	EPA 200.7 MET41	trans-1,3-Dichloropropene	EPA 524.2
Mercury	EPA 200.8 MET21	trans-Nonachlor	EPA 525.2
Methiocarb	EPA 531.1	Trichloroethene	EPA 524.2
Methomyl	EPA 531.1	Trichlorofluoromethane	EPA 524.2
Methoxychlor	EPA 508, 525.2	Trifluralin	EPA 508
Methyl Chloroform	EPA 524.2	Vinyl Chloride	EPA 524.2
Methyl Parathion	EPA 507	Zinc	EPA 200.7 MET41

Table 9. Air sampling for polycyclic aromatic hydrocarbons and volatile organic compounds at the Pentagon

Compound	Method	Compound	Method
1,2,4-Trichlorobenzene	EPA 8270B, TO-14, TO-1(Mod)	Di-n-octylphthalate	EPA 8270B
1,2-Dichlorobenzene	EPA 8270B, TO-14, TO-1(Mod)	Fluoranthene	EPA 8270B
1,3-Dichlorobenzene	EPA 8270B, TO-14, TO-1(Mod)	Fluorene	EPA 8270B
1,4-Dichlorobenzene	EPA 8270B, TO-14, TO-1(Mod)	Hexachlorobenzene	EPA 8270B
2,4,5-Trichlorophenol	EPA 8270B	Hexachlorobutadiene	EPA 8270B
2,4,6-Trichlorophenol	EPA 8270B	Hexachlorocyclopentadiene	EPA 8270B
2,4-Dichlorophenol	EPA 8270B	Hexachloroethane	EPA 8270B
2,4-Dimethylphenol	EPA 8270B	Indeno(1,2,3-cd)pyrene	EPA 8270B
2,4-Dinitrophenol	EPA 8270B	Isophorone	EPA 8270B
2,4-Dinitrotoluene	EPA 8270B	Naphthalene	EPA 8270B
2,6-Dinitrotoluene	EPA 8270B	Nitrobenzene	EPA 8270B
2-Chloronaphthalene	EPA 8270B	N-Nitrosodimethylamine	EPA 8270B
2-Chlorophenol	EPA 8270B	N-Nitrosodiphenylamine	EPA 8270B
2-Methyl-4,6-dinitrophenol	EPA 8270B	N-Nitrosodipropylamine	EPA 8270B
2-Methylnaphthalene	EPA 8270B	Pentachlorophenol	EPA 8270B
2-Methylphenol (o-Cresol)	EPA 8270B	Phenanthrene	EPA 8270B
2-Nitroaniline	EPA 8270B	Phenol	EPA 8270B
2-Nitrophenol	EPA 8270B	Pyrene	EPA 8270B
3-Nitroaniline	EPA 8270B	1,1,2,2-Tetrachloroethane	EPA TO-14
4-Bromophenyl-phenylether	EPA 8270B	1,1,2-Trichloroethane	EPA TO-14
4-Chloro-3-methylphenol	EPA 8270B	1,1-Dichloroethane	EPA TO-14, TO-1(Mod)
4-Chloroaniline	EPA 8270B	1,1-Dichloroethene	EPA TO-14, TO-1(Mod)
4-Chlorophenyl-phenylether	EPA 8270B	1,2,4-Trimethylbenzene	EPA TO-14, TO-1(Mod)
4-Methylphenol (p-Cresol)	EPA 8270B	1,2-Dibromoethane	EPA TO-14, TO-1(Mod)
4-Nitroaniline	EPA 8270B	1,2-Dichloroethane	EPA TO-14, TO-1(Mod)
4-Nitrophenol	EPA 8270B	1,2-Dichloropropane	EPA TO-14, TO-1(Mod)
Acenaphthene	EPA 8270B	1,3,5-Trimethyl Benzene	EPA TO-14, TO-1(Mod)
Acenaphthylene	EPA 8270B	4-Ethyltoluene	EPA TO-14
Anthracene	EPA 8270B	Acetone	EPA TO-14
Benzo(a)anthracene	EPA 8270B	Acetonitrile	EPA TO-14
Benzo(a)pyrene	EPA 8270B	Allylchloride	EPA TO-14
Benzo(b)fluoroanthene	EPA 8270B	Benzene	EPA TO-14, TO-1(Mod)
Benzo(g,h,i)perylene	EPA 8270B	Benzylchloride	EPA TO-14
Benzo(k)fluoroanthene	EPA 8270B	Bromomethane	EPA TO-14
Benzylalcohol	EPA 8270B	Carbon Disulfide	EPA TO-14
bis(2-Chloroethoxy)methane	EPA 8270B	Carbon Tetrachloride	EPA TO-14, TO-1(Mod)
bis(2-Chloroethyl)ether	EPA 8270B	Chlorobenzene	EPA TO-14, TO-1(Mod)
bis(2-Chloroisopropyl)ether	EPA 8270B	Chloroethane	EPA TO-14
bis(2-ethylhexyl)phthalate	EPA 8270B	Chloroform	EPA TO-14, TO-1(Mod)
Butylbenzylphthalate	EPA 8270B	Chloromethane	EPA TO-14
Chrysene	EPA 8270B	cis-1,2-Dichloroethene	EPA TO-14, TO-1(Mod)
Dibenz(a,h)anthracene	EPA 8270B	cis-1,3-Dichloropropene	EPA TO-14, TO-1(Mod)
Dibenzofuran	EPA 8270B	Dichlorodifluoromethane	EPA TO-14
Diethylphthalate	EPA 8270B	Dichlorotetrafluoroethane	EPA TO-14
Dimethylphthalate	EPA 8270B	Ethylbenzene	EPA TO-14, TO-1(Mod)
Di-n-butylphthalate	EPA 8270B	Hexachlorobutadiene	EPA TO-14

Table 9, continued. Air sampling for polycyclic aromatic hydrocarbons and volatile organic compounds at the Pentagon

Compound	Method
Methyl Chloroform	EPA TO-14, TO-1(Mod)
Methyl Ethyl Ketone	EPA TO-14
Methylene Chloride	EPA TO-14, TO-1(Mod)
Styrene	EPA TO-14, TO-1(Mod)
Tetrachloroethylene	EPA TO-14
Toluene	EPA TO-14, TO-1(Mod)
trans-1,2-Dichloroethene	EPA TO-14, TO-1(Mod)
trans-1,3-Dichloropropene	EPA TO-14, TO-1(Mod)
Trichloroethene	EPA TO-14, TO-1(Mod)
Trichlorofluoromethane	EPA TO-14
Trichlorotrifluoroethane	EPA TO-14
Vinylacetate	EPA TO-14
Vinyl Chloride	EPA TO-14
1,1,1,2-Tetrachloroethane	EPA TO-1(Mod)
1,1,2,2-Tetrachloroethane	EPA TO-1(Mod)
1,1,2-Trichloroethane	EPA TO-1(Mod)
1,1-Dichloropropene	EPA TO-1(Mod)
1,2,3-Trichlorobenzene	EPA TO-1(Mod)
1,2,3-Trichloropropane	EPA TO-1(Mod)
1,2-Dibromo-3-chloropropane	EPA TO-1(Mod)
1,3-Dichloropropane	EPA TO-1(Mod)
2,2-Dichloropropane	EPA TO-1(Mod)
2-Chlorotoluene	EPA TO-1(Mod)
4-Chlorotoluene	EPA TO-1(Mod)
4-Isopropyltoluene	EPA TO-1(Mod)
Bromobenzene	EPA TO-1(Mod)
Bromochloromethane	EPA TO-1(Mod)
Bromodichloromethane	EPA TO-1(Mod)
Bromoform	EPA TO-1(Mod)
Cyclohexane	EPA TO-1(Mod)
Cyclopentane	EPA TO-1(Mod)
Decane	EPA TO-1(Mod)
Dibromochloromethane	EPA TO-1(Mod)
Dibromomethane	EPA TO-1(Mod)
Hexachlorobutadiene	EPA TO-1(Mod)
Hexane	EPA TO-1(Mod)
Isooctane	EPA TO-1(Mod)
Isopropylbenzene	EPA TO-1(Mod)
m/p-Xylene	EPA TO-1(Mod)
Methylcyclopentane	EPA TO-1(Mod)
n-Butylbenzene	EPA TO-1(Mod)
n-Propylbenzene	EPA TO-1(Mod)
o-Xylene	EPA TO-1(Mod)
sec-Butylbenzene	EPA TO-1(Mod)
tert-Butylbenzene	EPA TO-1(Mod)
Tetrachloroethylene	EPA TO-1(Mod)

Appendix A. Characteristics of Jet A Fuel

Numerous jet fuels are used for military and civilian aircraft throughout the world. Jet A fuel (Jet A) is used by the civilian airline industry in the United States. Jet A and other aviation fuels fall into the "kerosene" category, a complex mixture of hydrocarbons (paraffinic, naphthenic, aromatics, and olefins) with boiling points ranging from approximately 300°F–550°F and an approximate carbon range of C_9–C_{16}. Differences in fuels include additives, volatility, freeze points, acidity, and lubricity, among others. There are numerous ASTM and DOD standards for aviation fuels; the Jet A standard is ASTM, D1655-11b (Standard Specification for Aviation Turbine Fuels) [ASTM 2011].

Kerosene-type fuels have low volatility because of the low vapor pressure and higher molecular weights. Dermal exposures tend to be the highest concern as jet fuel is a skin irritant [IARC 1989; API 2010; ACGIH 2011b]. However, under specific conditions such as high temperatures, high vapor concentrations, aerosol production, and confined spaces, exposure by inhalation can be of concern [ACGIH 2011b]. Exposure by inhalation can produce respiratory irritation and central nervous system depression [ACGIH 2011b]. Numerous studies have evaluated occupational exposures to U.S. Air Force personnel using JP-8 fuel (primary jet fuel for military aircraft) [Carlton and Smith 2000; McDougal et al. 2000; Pleil et al. 2000; Egeghy et al. 2003; Serdar et al. 2003; Tu et al. 2004; Chao et al. 2005; Chao et al. 2006; Proctor et al. 2011; Smith et al. 2010; Smith et al. 2012]. In their review of many of these studies, Smith et al. [2010] indicate these studies show variable exposures to personnel conducting different tasks associated with JP-8 fuel. Studies tend to characterize exposures to naphthalene, BTEX, and THC. Studies suggest that napthalene be used as a biomarker of exposure as it is a main component of jet fuel and because of its readiness for absorption into the blood.

API jet fuel reports to the EPA and an EPA hazard characterization document (in collaboration with the API reports) addresses the environmental fate of jet fuels [API 2010a,b; EPA 2011]. In summary, the reports indicate that after entry into the environment, the individual components of kerosene/jet fuel will disperse and partition based upon each individual compound's physical-chemical properties. Degradation would be based upon photodegradation, water solubility, environmental distribution, and biodegradation. Direct photodegradation (structural transformation based on absorption of light energy) would not play a large role. Indirect photodegradation (reaction with hydroxyl radicals) is a more likely pathway for hydrocarbon degradation. Water solubility is not a degradation pathway as hydrocarbons in the kerosene/jet fuel category do not undergo hydrolysis. Modeling data suggest that within the kerosene/jet fuel range of C_9–C_{16}, the tendency is to partition to air more readily at C_9 and more readily to soil as the number of carbon atoms increases up to C_{16}.

The reports suggest that under the appropriate conditions, kerosene/jet fuel hydrocarbons are inherently biodegradable. The documents do provide tables reporting specific data on the photodegradation, water solubility, environmental distribution, and biodegradation of kerosene/jet fuel compounds.

Agencies and professional organizations developing standards or providing recommended limits vary on their approach to addressing jet fuels. OELs vary from inclusion of all kerosene-based fuels, fuel specific (JP-8 and DOD), comparative criteria (Stoddard solvent), and individual components of fuels (benzene, naphthalene, toluene, xylenes, etc.). There do not appear to be any exposure standards set specifically for Jet A. ACGIH and the API do not differentiate between the kerosene-based fuels [API 2010; ACGIH 2011a]. The ACGIH TLV for kerosene/jet fuels is 200 mg/m^3 of total hydrocarbon vapor, but is limited to conditions where there are negligible aerosol exposures and may not be applicable when exposures are short term under high concentrations [ACGIH 2011a,b]. ACGIH lists a skin notation and an A3 designation (confirmed animal carcinogen with unknown relevance to humans) to its kerosene/jet fuel TLV. The API Petroleum High Production Volume Testing Group, in their submission to EPA, suggests that the similarities between kerosene-based fuels allow for the extrapolation of toxicological data between fuels [API 2010]. It is unclear whether the DOD continues to use its 8-hour TWA OEL for JP-8 of 350 mg/m^3 [NRC 1996, 2003]. Smith et al. [2010] indicate that the U.S. Air Force recommends 200 mg/m^3 as their OEL for JP-8 fuel. OSHA does not have OELs for jet fuel or kerosene, but has a Stoddard solvent PEL of 2,900 mg/m^3 [29 CFR 1910.1000]. NIOSH does not have a REL for jet fuel, but has a kerosene REL of 100 mg/m^3 and Stoddard solvent REL of 350 mg/m^3 with a ceiling (15-minute) of 1,000 mg/m^3. IARC lists jet fuel as a Group 3 substance (inadequate evidence for the carcinogenicity in humans) [IARC 1989].

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Appendix B. Pentagon Responder List (unofficial)

Fire Departments

Virginia

Aldie Volunteer Fire Department
Alexandria Volunteer Fire Department
Annandale Volunteer Fire Department
Arcola-Pleasant Valley Volunteer FD
Arlington County Emergency Medical Services
Arlington County Fire Department
Arlington Volunteer Fire Department
Ashburn Volunteer Fire Department
Bailey's Crossroads Volunteer Fire Department
Ballston Volunteer Fire Department
Buckhall Volunteer Fire Department
Burke Volunteer Fire Department
Centreville Volunteer Fire Department
Cherrydale Volunteer Fire Department
Clarendon Volunteer Fire Department
Coles District Volunteer Fire Department
Dale City Volunteer FRD
DC Emergency Medical Services
Dumfries-Triangle Volunteer Rescue Squad
Dunn Loring Volunteer Fire Department
Evergreen Volunteer Fire Department
Fair Oaks Volunteer Fire Department
Fairfax City Fire Department
Fairfax County Fire and Rescue Department
Fairlington Volunteer Fire Department
Falls Church Volunteer Fire Department
Fort Myer Fire Department
Franconia Volunteer Fire Department
Gainesville District Volunteer Fire Department
Great Falls Volunteer Fire Department
Greater Springfield Volunteer Fire Department
Hamilton Volunteer Fire Department
Hamilton Volunteer Rescue Squad
Jefferson Volunteer Fire Department
Lake Jackson Volunteer Fire Department
Leesburg Volunteer Fire Department
Lorton Volunteer Fire Department
Loudoun County Fire and Rescue Services
Lovettsville Volunteer Fire Department
Lucketts Volunteer Fire Department
Manassas Park Fire Department
Manassas Volunteer Fire Department
McLean Volunteer Fire Department
Metropolitan Airport Authority Fire Unit
Middleburg Volunteer Fire Department
Neersville Volunteer Fire Department
Nokesville Volunteer Fire Department
Occoquan-Woodbridge-Lorton Volunteer FD
Philomont Volunteer Fire Department
Prince William County FRD
Purcellville Volunteer Fire Department
Purcellville Volunteer Rescue
Round Hill Volunteer Fire Department
Sterling Volunteer Fire Department
Sterling Volunteer Rescue Squad
Stonewall Jackson Volunteer Fire Department
Yorkshire Volunteer Fire Department

Maryland

Bethesda Chevy Chase Rescue Squad
Bethesda Fire Department
Branchville Volunteer Fire Department
Burtonsville Volunteer Fire Department
Cabin John Park Volunteer Fire Department
Chevy Chase Fire Department
Cottage City Volunteer Fire Department
Damascus Volunteer Fire Department
Gaithersburg-Wash Grove Vol. Fire Department
Germantown Volunteer Fire Department
Glen Echo Volunteer Fire Department
Greenbelt Volunteer Fire Department
Hillandale Volunteer Fire Department
Hyattstown Volunteer Fire Department
Kensington Volunteer Fire Department
Kentland Volunteer Fire Department
Laytonsville Volunteer Fire Department
Montgomery County Division of Volunteer FRS
Morningside Volunteer Fire Department
Rockville Volunteer Fire Department
Sandy Spring Volunteer Fire Department
Silver Spring Volunteer Fire Department
Takoma Park Volunteer Fire Department
Upper Montgomery County Volunteer FD
Wheaton Volunteer Rescue Squad
Woodsboro Volunteer Fire Company

Agencies, Departments, Programs

Alexandria Technical Response Team
Alexandria Office of Virginia's Alcohol Beverage and Control Board
Arlington County Sheriff's Office
Arlington Police Department
Arlington Technical Response Team
Armed Forces Institute of Pathology
Armed Forces Medical Examiner
Building Operations Command Center
Bureau of Alcohol, Tobacco, and Firearms
Defense Protective Service
DiLorenzo Tricare Clinic
DOD Honor Guard
Drug Enforcement Agency
Environmental Protection Agency
Federal Bureau of Investigation
Maryland Task Force 1
Military District of Washington Rescue Unit
National Capital Response Squad
National Medical Response Team
National Naval Medical Center
National Transportation Safety Board
New Mexico Task Force 1
North Atlantic Regional Medical Command
Occupational Safety and Health Administration
Pentagon Family Assistance Center
Pentagon Medical Staff
Pentagon Renovation Program Office
Rader Army Health Clinic Staff
Red Incident Support Team
SACE Structural Safety Engineers and Debris Planning and Response Teams
Salvation Army
Special Medicine Augmentation Response Team-Preventive Medicine
Tennessee Task Force 1
Uniformed Services University of the Health Sciences
U.S. Air Force Office of Special Investigations
U.S. Army Corps of Engineers
U.S. Army Center for Health Promotion and Preventive Medicine
U.S. Army Chaplains
U.S. Forest Service Type 1 Incident Management Team
U.S. National Guard units
U.S. Park Police
U.S. Secret Service
Virginia Department of Emergency Management
Virginia Department of Environmental Quality
Virginia Task Force 1
Virginia Task Force 2
Walter Reed Army Medical Center
Washington Headquarters Services

American Red Cross

Virginia

Arlington County Chapter, Arlington
Alexandria Chapter, Alexandria
American Red Cross of the Blue Ridge, Staunton
Historic Virginia Chapter, Bedford
Mountain Empire Chapter, Bristol
Central Virginia Chapter, Charlottesville
Culpepper-Madison Chapter, Culpepper
Fauquier Chapter, Warrenton
Rappahannock Area Chapter, Fredericksburg
Hampton Roads Chapter, Newport News
Loudoun County Chapter, Leesburg
Martinsville-Henry County Chapter, Martinsville
Montgomery-Floyd Chapter, Blacksburg
Prince William County Chapter, Manassas
Radford Chapter, Radford
Greater Richmond Chapter, Richmond
Roanoke Valley Chapter, Roanoke
Southeastern Virginia Chapter, Norfolk
Colonial Virginia Chapter, Williamsburg
Winchester-Frederick County, Winchester
York-Poquoson Chapter, Yorktown
American Red Cross of the National Capitol, Fairfax

Maryland

Central Maryland Chapter, Baltimore
American Red Cross of Southern Maryland, La Plata
Frederick County Chapter, Walkersville
Washington County Chapter, Hagerstown
Lower Shore Chapter, Salisbury

Hospitals

Andrew Rader U.S. Army Health Clinic
Arlington Urgent Care
George Washington University Hospital
Inova Alexandria Hospital
Inova Emergency Care Center (HealthPlex)
Inova Fairfax Hospital
Northern Virginia Community Hospital
Virginia Hospital Center - Arlington
Washington Hospital Center

Pentagon Contractors

Wedge 1 and Phoenix Project

AMEC – Project Lead
ACM Services
ACECO LLC
AMEC Earth & Environmental
Bragunier Masonry Const., Inc.
C.J. Coakley
Capco Contracting Company
Commercial Hardware
CPF
CRT
Curtis Equipment Company
ECS Ltd.
EDG
Ernest Lee Tile Company
Facchina Construction, Inc.
GHT
Glode Iron Const. Company
HDK
Home Engineers, Inc.
J.C. Campos Construction
Jewell
John J. Kirlin, Inc.
KCE Structural Engineers
Key Woodworking, Inc.
Law
Linel Signature Skylite
Masonry Arts
Morgan Maintenance
Mufti International, Inc.
Oehrlein & Associates
Overhead Door of DC
Prospect Waterproofing Company
Robb Associates
Rockville Partitions, Inc.
Roman Mosaic and Tile Company
ROSH Construction
RTKL
Singleton Electric Company
Stanton Engineering
Swinging Door, Inc.
Syska Hennessey
Tristate
VIKA Incorporated
Weidlinger Associates, Inc.
Weihe Design Group
Winstead
Won Dor
Zanes Specialties

Wedges 2-5

Hensel Phelps Construction Company – Project Lead
Air Services, Inc.
Ammon Painting Company
CAPCO Contracting Company, Inc.
Custom Walls & Windows, Inc.
Dulles Drywall, Inc.
EnviroBate Global, Inc.
HDR Architecture, Inc.
LVI Environmental Services, Inc.
M.C. Dean, Inc.
National Fire Protection, Inc.
Performance Contracting
Shalom Baranes Associates, Inc.
Southland Industries
Studios Architecture

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Appendix C. Shanksville Responder List (unofficial)

Fire Departments

Berlin Volunteer Fire Department
Central City Volunteer Fire Department
Friedens Volunteer Fire Company
Hooversville Rescue Squad
Hooversville Volunteer Fire Department
Listie Volunteer Fire Company
Shanksville Volunteer Fire Company
Somerset Ambulance Association
Somerset Volunteer Fire Department
Stoystown Volunteer Fire Company

Agencies, Departments, Programs

Air, Search & Rescue – Canine & Helicopter
American Red Cross
Bedford Somerset County MH/MR – Mental Health/ Mental Retardation
    CERT – Community Emergency Response Team
    CISM – Crisis Incident Stress Management
Bureau of Alcohol, Tobacco, and Firearms
Cambria County Coroner's Office
Camp Cadet of Somerset County
Carnegie Mellon University
Civil Air Patrol
Disaster Mortuary Operational Response Team, Region III
Drug Enforcement Agency
Environmental Protection Agency
Environmental Resource Management
Fayette County Emergency Management Agency
Federal Aviation Administration
Federal Bureau of Investigation - Pittsburgh, Cleveland, Chicago, Detroit, Knoxville, Louisville, Cincinnati
Federal Emergency Management Agency
GPU Energy
Indian Lake Borough Police
J & J Svonavec Excavating, Inc.
Local Clergy
Motorola
National Transportation Safety Board
Network of Victim Assistance
Occupational Safety and Health Administration
Office of State Fire Commissioner
Office of the Armed Forces Medical Examiner
Paint Township Police
PBS Coals, Inc.
Penelec
Penn State University Arborists
Pennsylvania Board of State Funeral Directors
Pennsylvania Dental Association Dental Identification Team

Pennsylvania Department of Environmental Protection, Southwest Region
Pennsylvania Department of Transportation
Pennsylvania Emergency Management Agency/Pennsylvania Lt. Governor
Pennsylvania Game Commission
Pennsylvania National Guard
Pennsylvania Region 13 Task Force
Pennsylvania State Police – Patrol, Mounted Unit, Aviation Unit, Reconstructionists
Pittsburgh Critical Incident Stress Management Team
Rollock, Inc.
Salvation Army
Shade Township Police
Somerset County Commissioners
Somerset County Coroner's Office
Somerset County D.A.
Somerset County Emergency Management Agency
Somerset County Solicitor
Somerset Electric
Somerset Hospital
Somerset Rural Electric Cooperative
Somerset County Sheriff's Department
Stonycreek Township Supervisors
The Cat Rental Store
U.S. Attorney General
U.S. Navy Seals
University of Pittsburgh Medical Center Medical Support Team
United Airlines
Verizon

American Red Cross

Hazleton Chapter, Hazleton
Armstrong County Chapter, Kittanning
Beaver-Lawrence Chapter, Beaver
Berks County Chapter, Reading
Southern Alleghanies Chapter, Altoona
American Red Cross in McKean-Potter Counties, Bradford
Bradford-Sullivan Counties Chapter, Monroeton
Butler County Chapter, Butler
Clearfield-Jefferson Chapter, Clearfield
Corry Chapter, Corry
Cumberland County Chapter, Carlisle
Du Bois Chapter, Dubois
Greater Erie County Chapter, Erie
Franklin County Chapter, Chambersburg
Hanover Chapter, Hanover
Indiana County Chapter, Indiana
Keystone Chapter, Johnstown
American Red Cross of Susquehanna Valley, Lancaster
Lebanon County Chapter, Lebanon
ARC of the Greater Lehigh Valley, Bethlehem
Lower Bucks County Chapter, Levittown
North Central Pennsylvania Chapter, Williamsport
Middletown Area Chapter, Middletown
Monroe County Chapter, Stroudsburg
Allegheny Region Chapter, Reno
Southwestern Pennsylvania Chapter, Pittsburg
Elk-Cameron Counties Chapter, St. Marys
Scranton Chapter, Scranton
Snyder County Chapter, Middleburg
Southeastern Pennsylvania Chapter, Philadelphia
American Red Cross in Schuylkill County and Easter, Pottsville
Centre Communities Chapter, State College
Susquehanna County Chapter, Montrose
Union County Chapter, Lewisburg
Wayne Pike Chapter, Honesdale
Westmoreland County Chapter, Greensburg
Wyoming Valley Chapter, Wilkes-Barre
York County Chapter, York

Appendix D. Exposure Publications

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