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Intelligence Update: Chemical Warfare Agent Issues During the Persian Gulf War

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Introductory Note

Since 1993, much attention has been focused on chemical warfare (CW) agents as a potential cause of, or contributor to, Gulf war illnesses (GWI). In spring 1995, the CIA initiated a comprehensive study of intelligence and other information to help determine whether US troops were exposed to any chemical, biological, or radiological agents and to examine intelligence for any potential causative factors of Gulf war illnesses. In February 1997, the Intelligence Community (IC) formed the Persian Gulf War Illnesses Task Force to study and declassify intelligence potentially relevant to veterans' illnesses issues and to expedite sharing of intelligence with the Department of Defense (DoD). In April 1997, the Task Force published a detailed unclassified paper on intelligence related to the Khamisiyah Storage Depot. The Task Force also studied potential releases of nerve agents at Khamisiyah, continued research on potential toxic agent exposure, and produced and declassified numerous other papers related to veterans' issues.

This paper reflects the results of our multifaceted investigation into the CW issue, examining information on CW agent releases, Gulf war Iraqi CW deployments, and Iraqi chemical agents and weapons. Results of our studies on biological and radiological agents have been published in separate reports. With the publishing of this paper, the DCI Persian Gulf War Illnesses Task Force has completed its work. Hereafter, Office of the Secretary of Defense (OSD) intelligence tasking on this topic will follow standard procedures with the Defense Intelligence Agency. In addition, the IC will continue to review new intelligence for information pertinent to Gulf war veterans' illnesses in order to bring it to the attention of OSD. It has been my pleasure working to advance the understanding of possible causes of Gulf war illnesses.

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Scope Note

This paper addresses the possibility of exposure only to chemicals generally accepted—or treated by Iraq—as chemical warfare agents. Releases of industrial chemicals, chemical agent precursors, and other chemicals are not addressed. In addition, this paper does not cover exposure to chemical agents by the small number of special operations forces (SOF) deployed behind enemy lines, because we lack detailed information on their locations. Thus, when we refer to "US troops" in the context of proximity to CW agent releases, we are excluding SOF units deployed away from most of the Coalition forces. We do indicate where DoD modeling has caused them to be concerned about possible exposure on one release event. We defer to DoD to determine any potential exposure by SOF troops from unmodeled events.

Key Findings

After conducting a multiyear study, we assess that CW agents reached US Persian Gulf war troops[1] in only one case—the 10 March 1991 inadvertent release of nerve agent from the US demolition of Iraqi chemical rockets in a pit at the Khamisiyah Depot in Iraq. That release resulted in low-level nerve agent contamination of a significant area as published in the joint DoD-IC paper *Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit*, 4 September 1997. In 2000, DoD published revised modeling of the Khamisiyah Pit release using updated CIA source assessments; this new modeling indicates that the area used for troop notification of potential low-level exposure[2] has decreased by roughly half compared to the results published in 1997. However, the number of US troops to which DoD sent letters of notification actually increased slightly because of better information about their locations.

Iraqi Chemical Agents. The primary Iraqi chemical agents available for release at the time of Desert Storm were the blister agent sulfur mustard; the mixed nerve agents sarin and "cyclosarin" (also known as GB and GF, respectively); and the riot control agent CS—all well-known compounds.[3] In addition, investigations of ballistic missile warhead fragments by the former United Nations Special Commission on Iraq (UNSCOM) indicate a few warheads were filled with VX. It is unlikely that Iraq filled any weapons with other chemical agents, including any potential "exotic" chemical agents. We have no reliable information on chemical agents developed to cause long-term illnesses.

New Assessments of Chemical Agent Releases. Our study identified many possible releases of chemical agent from Coalition action or incidental causes (see figure 1). Other than the previously mentioned Khamisiyah Pit release, the most significant release locations—Khamisiyah Bunker 73, Muhammadiyat, and Al Muthanna Bunker 2—were identified and assessed in previous CIA and IC reporting on Gulf war illnesses (see Bibliography).[4] However, we have significantly decreased our estimate of nerve agent release amounts at the sites on the basis of additional analysis and subsequent information from UNSCOM. At Muhammadiyat, where Coalition bombing also damaged mustard[5] bombs, our assessed mustard release amount has increased. Modeling and weather information—including 2000-2001 DoD modeling of Al Muthanna and Muhammadiyat using the revised release amounts—indicates contamination from these releases did not reach US troops.[6]

We completed a rigorous search for additional Gulf war CW agent releases—no matter how small—and have identified

additional releases. Only one of these additional releases was the result of Coalition military action—a release of mustard agent resulting from aerial bombing of the production plant at Al Muthanna. All other new releases involved leakage of defective Iraqi munitions. We assess these releases did not reach US troops because they were too small, too slow, or too far from US troops. We also identified several suspect release sites—related to Iraq's declared unilateral destruction of chemical munitions—and we assess these also are unlikely to have been an exposure threat.

Additional Major Releases Unlikely. Intelligence and UNSCOM information provide no basis for suspecting that stores of undiscovered munitions or bulk chemical agent were damaged during the Gulf war. We believe that Iraq generally tried to declare all damaged—and therefore useless—chemical munitions to demonstrate compliance with UN resolutions. In addition, given the detailed reliable information available on many aspects of Iraq's CW program, it is unlikely that, during Desert Storm, there were additional chemical-agent-filled munitions close to or within the Kuwait Theater of Operations. Thus, we assess that additional Gulf war–era releases of chemical agents large enough to threaten exposure to US troops are unlikely, although additional small chemical releases may be identified.

No Chemical Weapons Use. On the basis of intelligence, UNSCOM, and DoD information, we continue to assess that Iraq did not use chemical weapons against Coalition troops. Iraqi use of mustard or nerve agents against Shiite insurgents immediately after Desert Storm is also unlikely.

Coalition Reports of CW. On numerous occasions, Coalition troops reported potential detection of, or exposure to, CW agents during military operations in the Persian Gulf. After reviewing DoD investigations, intelligence information, and testimony or reports from Congress, Presidential committees, and the press, we have not found any event we assess to be related to chemical agents or weapons. The IC will continue to support future DoD investigations related to such reporting.

We now assess that two Coalition incidents that we previously considered credible CW events—Czech CW detections in January 1991 and the blistering of a US soldier at the Iraq-Kuwait border in early March 1991—are unlikely to have involved chemical agents.

- Our extensive investigations into possible release locations of chemical agent failed to identify a plausible source of release for any of the well-known Czech detections in Saudi Arabia and essentially rule out releases from aerial bombing of Iraqi facilities. In addition, new information contradicts previous information about the detections and point to constraints in the detection system that are the most likely cause of the positive readings.
- We now assess that the US soldier's blisters were not caused by mustard agent because intelligence and UNSCOM information indicate that mustard was not at this location. In addition, we assess that the Fox mobile detector information and initial medical evaluation were less compelling than later laboratory testing on garments and analyses of the Fox data, which indicate that mustard was not involved.

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Potential Chemical Agent Releases

This report updates previously published assessments by CIA and this Task Force on CW release sites, including Khamisiyah, Al Muthanna, and Muhammadiyat. In addition, we identified and documented additional Gulf war releases—no matter how small or unlikely to reach troops. These new releases (shown in red italics in table 1) resulted from a comprehensive review of previously known information—such as that found on the GulfLINK Web site

(www.gulflink.osd.mil)—as well as information subsequently uncovered by UNSCOM. In some cases we have sufficient data to conclude that a release was **definite**, while others can only be characterized as **suspect** events. With the exception of the release of mustard agent resulting from aerial bombing of the production plant at Al Muthanna, the only new definite releases involve leakage of defective Iraqi munitions. New suspect releases all relate to Iraq's declared unilateral destruction of munitions.

Iraqi Chemical Agents and Gulf War Illnesses

After a comprehensive review of Iraqi CW agent production and storage, we conclude that, at the time of Desert Storm, Iraq possessed usable stocks of only five chemical agents—the blister agent sulfur mustard (HD); the nerve agents sarin (GB), cyclosarin (GF), and VX,[a] and the riot control agent CS. On the basis of extensive intelligence and UNSCOM information, we believe it is very unlikely that Iraq had any other agents in its CW inventory. We also compiled a list of CW agents—presented in appendix A—that might have been present in trace quantities (as impurities or degraded chemical agent) or that were researched by Iraq and could have been available in laboratory quantities. We found no credible evidence that Iraq had substantial amounts of "exotic" chemical agents that could explain the symptoms experienced by the Gulf war veterans. As shown in appendixes A and B, Iraq researched a wide array of chemicals for its CW program but we assess none were specifically intended to cause chronic long-term illnesses. The vast majority of the compounds produced or researched by Iraq for CW purposes are traditional chemical agents or similar compounds whose immediate effects from high-level exposure are fairly well understood. One major exception is 3,3'-iminodipropionitrile (IDPN)—a chemical rarely associated with CW—which Iraq claimed it researched as a psychochemical. Limited experimental data is available showing that IDPN has a wide range of neurological and general physiological effects when given to laboratory animals in fairly large doses.[b] It is unlikely this compound ever passed the research stage or was produced in significant quantities.

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[a] ***On the basis of UNSCOM analysis of container fragments and other information, we assess that Iraq had filled at least some warheads for the Al Husayn missile with VX. However, we believe that the amount of VX Iraq had at the time of the war was small as compared to the other agents in its stockpile.***

[b] ***In large quantities IDPN has been known to affect memory, motor control, body weight, muscle tone, urination, hearing, sense of smell, and general activity; cause birth defects; and, on a cellular level, produce effects in rats similar to those observed in ALS (amyotrophic lateral sclerosis, commonly known as Lou Gehrig's disease).***

Table 1 summarizes our assessments of release and exposure at each site (see figure 1 for a map showing locations). The munitions involved in these releases contained about 8 percent of the more than 700 metric tons of Iraqi chemical fill (agent and impurities) stored in chemical munitions and bulk containers at the time of the war. We assess that less than 6 tons of actual chemical agent was released into the atmosphere. The low percentage of chemical agents released—despite sustained Coalition efforts to destroy chemical weapons—is due to a number of factors, including Iraqi dispersal of chemical weapons to avoid their destruction, low nerve agent purity, and fire and environmental degradation of chemical agent (see appendix C).

Computer modeling[7] by CIA and DoD indicates that, with the exception of the Khamisiyah Pit release,[8] no modeled release revealed even low-level exposure of US forces to CW agents. CIA weather modeling of the Khamisiyah Bunker 73 release indicates contamination was blown away from US troops. CIA and DoD modeling of other estimated chemical agent

releases from Muhammadiyat and Al Muthanna indicate contamination fell short of or was blown away from US troops. Our confidence in these assessments has been improved through the use of worst-case inputs and efforts to account for modeling and troop location uncertainty.

Extensive previous modeling leads us to conclude that the other unmodeled CW releases and suspect releases were too small and distant to expose US troops. Using previous modeling of potential release events throughout the entire air war, we can estimate—without complex computer modeling—a worst case of how far contamination from a given amount of chemical agent would extend. Comparing the modeled events to the unmodeled events indicates that unmodeled release sites are too remote for chemical contamination to have reached US troops for the estimated release amounts. More information about release parameters (date, amount, rate, etc.) and previous modeling can be found in the body of this paper, the GulfLINK Web site, appendix C and other appendixes, and in reports cited in the bibliography. In addition, appendix D provides an overview of the assessed locations of Iraq's chemical munitions inventory during Desert Storm.

Khamisiyah Pit Nerve Agent Release

As can be seen from table 1, the Khamisiyah Pit (see figure 2) demolition of 10 March 1991 remains the only CW agent release incident where troops probably were exposed to low levels of nerve agent at or slightly above the general population limit (GPL), (see box). (For background on this incident, please see CIA publications *Khamisiyah: A Historical Perspective on Related Intelligence*, 9 April 1997, and *Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit*, July 1997.) The 2000 DoD modeling using updated source terms indicates that the potential contaminated area—derived from combined models—is about half the size of the 1997 modeling results, though the number of potentially exposed troops remained about the same because of updated troop location information. The smaller area results from a combination of factors:

- Additional UNSCOM information—including a 1998 inspection—indicates that the maximum amount of nerve agent released was about half the amount modeled in 1997. We now assess that only 225 rockets released agent, rather than the 500 we estimated in 1997 (see appendix E for more details).
- Post-1998 computer modeling includes the effects of natural GB/GF nerve agent decay and other environmental factors that reduce contamination as compared to 1997 models that excluded such factors. A 1998 CIA-sponsored analysis of daytime GB/GF degradation allowed daytime decay estimates to be included in the recent modeling.
- DoD reassessed the threshold general population limit (GPL) dosage values for sarin and cyclosarin, resulting in increases of over 200 percent and 11 percent, respectively (see box). The higher GPL threshold reduces the low-level (GPL) exposure area.

We note that the area depicted by both the 1997 and 2000 DoD models is much larger than we expect of the actual extent of contamination. To account for differences in models, the published areas represent a composite of GPL contamination areas from multiple separate models. In addition, most of the modeled contamination areas were enlarged to account for weather uncertainties.[9] Finally, the composite area was further expanded by several kilometers to help account for uncertainty in troop location. The IC agreed to the combined contamination area to account for some modeling differences and to provide epidemiologists a best estimate of which US troops were at risk of exposure to CW agents for their studies. This composite area was not intended to be used to estimate the absolute number of US troops exposed to CW agents. In fact, the actual number of US troops within the areas actually covered by low levels of CW agents is less than that derived from the composite area. Nevertheless, given the modeling uncertainties involved, we continue to assess that a composite provides more meaningful information to the epidemiologists involved in this effort than a single estimated area.

Khamisiyah Bunker 73 Nerve Agent Release

US soldiers unknowingly destroyed nerve-agent-filled rockets in Bunker 73 at Khamisiyah on 4 March 1991 (see figure 2). CIA's 1996 analysis and weather modeling indicated that the wind carried nerve agent to the northeast (away from troops) and that US troops were not exposed. On the basis of UNSCOM information from 1998, we have updated our assessment of the release of agent at Bunker 73. We now assess that the amount of agent released is about one-twentieth that used in the

1996 contamination modeling, primarily because UNSCOM found that hundreds of nerve-agent-filled rockets still remained in the bunker in 1998; in addition, we were able to derive better estimates of the percentage of nerve agent actually released when munitions were destroyed (see appendix F for additional details).

Al Muthanna Production/Filling/Storage Facility Chemical Agent Releases

Previous CIA assessments indicated that nerve agent was released only from Bunker 2 at this huge chemical agent production, storage, and filling facility. Our 1996 worst case modeling of this release indicated that low levels of nerve agent would not have reached US troops. Subsequent UNSCOM information and detailed bunker fire modeling by a CIA contractor indicate that about 40 times less agent probably was released than estimated in 1996. 2001 DoD modeling using this new release amount indicates that US troops were not exposed to even low levels of nerve agent.

As part of the IC's comprehensive study we identified additional releases of chemical agents from the Al Muthanna facility (see appendix G). However, we assess these releases were too small, slow, and distant to reach US troops. UNSCOM information leads us to conclude that mustard agent was released as a result of Coalition bombing of the mustard production plant at Al Muthanna. In addition, small amounts of chemical agents leaked from defective munitions and containers at various locations at Al Muthanna. Release of chemical agents from other production plants and filling facilities is unlikely, but releases of small amounts from incompletely cleaned production and filling equipment cannot be ruled out. UNSCOM information indicates that Al Muthanna's bulk containers—which held tons of chemical agent—were undamaged because Iraq buried most of them away from structures to protect them from Coalition precision bombing.

Muhammadiyat Probable Nerve and Mustard Agent Releases

On the basis of 1996 modeling of contamination from the Muhammadiyat nerve and mustard agent releases, we assessed that US troops probably were not exposed to even low levels of chemical agents from releases at this site. Subsequent joint DoD/CIA analysis has refined our estimates of the amount of nerve and mustard agents released as a result of Coalition bombing. The estimated maximum amount of nerve agent released has decreased from 290 kg to 180 kg, while the amount of mustard agent released has increased from about 1,500 kg to 3,000 kg (see appendix H). Better information on agent purity, number of bombs, and release percentage led us to reduce the estimated amount of nerve agent released. The increased mustard is a result of determining—contrary to previous Iraqi declarations—that about 270 additional mustard bombs burned because of Coalition bombing. Iraq may have confused these burned bombs with hundreds of other chemical bombs burned at an adjacent bunker during the Iran-Iraq war. Even with the increased mustard agent release amount, we assess that exposure from this release was unlikely on the basis of 2001 DoD modeling using this larger amount. DoD indicates that 2001 modeling shows that US troops were not exposed to low levels of nerve agents released from Muhammadiyat.[10]

Ukhaydir Depot Nonrelease of Mustard

Contrary to our 1997 assessment, we now judge that it is unlikely that Coalition bombing of Ukhaydir released mustard from 155-mm artillery munitions. Our new assessment is based on several factors:

- Lack of any indications of damaged munitions during a thorough 1998 UNSCOM excavation at Ukhaydir, including searches with sophisticated ground-penetrating radar.
- Iraqi denial of any wartime damage to mustard shells at Ukhaydir, despite pressure to account for 550 shells Iraq declared were damaged during the Gulf war.
- Indications from intelligence information that likely stacks of mustard shells were probably not directly damaged by a nearby bombing-induced bunker fire or a separate bomb explosion under a road.

In addition, we no longer believe that empty 155-mm shells found by UNSCOM are related to Desert Storm aerial attacks at

Ukhaydir—a worst case assumption we made in 1997. On the basis of their external appearance and Iraqi declarations, we conclude that these munitions—some empty green shells and others burned shells—probably were holdovers from the Iran-Iraq war or were damaged elsewhere. For more information see appendixes I and J.

Al Walid Suspected Nerve Agent Release

UNSCOM examination of its inspection photographs at Al Walid Airbase indicates a few of the approximately 160 binary (alcohol-filled) bombs may have released nerve agent.[11] These bombs probably were damaged as a result of Coalition bombing—consistent with Iraqi claims. However, we need further information before we can make a determination that bombing caused a nerve agent release. Nevertheless, even if a release did occur, we conclude it would have been too small to reach US troops in Saudi Arabia. Additional details are provided in appendix K.

Leaking Iraqi Chemical Munitions and Bulk Containers

UNSCOM inspectors found leaking munitions at six different facilities; most leaks were the result of munition defects and harsh storage conditions. The most significant CW leak involved release of mustard at the Al Tuz Airbase—the most northerly of the leakage sites. This probably resulted from Iraqi bulldozing of munitions during burial. Even though the leaking munitions released relatively small amounts of CW agent from sites distant from deployed US troops, we present information on these events in appendix L.

What Is "Low-Level" Nerve Agent Exposure?

The threshold we use to define "low-level" in this report is the DoD's general population limit (GPL) dosage, which for sarin is 20 times lower[a] than the "first effects" level—the smallest dose of agent causing noticeable immediate (acute) effects, such as miosis (pinpointing of pupils). the GPL was originally intended for monitoring potential public exposure to US chemical agents. It was calculated by applying numerous safety factors to the first-noticeable-effects level to establish a level at which the general population could be exposed 24 hours a day for a lifetime without experiencing any adverse health effects. DoD and CIA selected the GPL as our threshold because it was a scientifically based standard. Although there is very little information to link GPL or first-effects levels of nerve agents to long-term illnesses, DoD and VA are conducting studies to better understand the consequences of such exposure.

The GPL used in our 1996 and 1997 modeling of nerve agents[b] was originally set as an Army safety limit of 0.013 mg-min/m3 for sarin (GB) and cyclosarin (GF)[c]—equaling exposure to a concentration of 0.000003 mg/m3 for a three-day period. DoD subsequently has increased the GPL dosage by about 11 percent for GF (to 0.0144 mg-min/m3) and by 233 percent for GB (to 0.0432 mg-min/m3). As previously mentioned, the GPL level is only a safety level and was not set on the basis of known increases in occurrence of long-term illnesses above this level.

Nerve Agent GPL Dosage Values Used for Modeling

Agents	*Modeling Year*	*Adjusted* Concentration*	*Time Basis*	*Dosage*
GB and GF	*1996/1997*	*0.000003mg/m3*	*72 hr*	*0.013mg-min/m3*

GB	*2000/2001*	*0.00003mg/m3*	*24 hr*	*0.0432mg-min/m3*
GF	*2000/2001*	*0.00001mg/m3*	*24 hr*	*0.0144mg- min/m3*

** Current GPL concentrations are adjusted for the fact that the Gulf war exposures are short duration as opposed to the lifetime exposure assumed in calculating the original level.*

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[a] Dosage is the product of agent concentration and time (duration) of exposure. Dosage relates to the amount and, thus, the effect of a toxin entering the body. In the context of CW agent releases, concentration refers to the weight of agent per unit volume of air. The first-effects concentration level is 3,000 times smaller than the GPL concentration level but exposure time is 144 times less, thus resulting in a factor of 20 difference in dosage.

[b] The 1996 and 1997 GPL level for mustard agent was set at 0.432 mg-min/m3. The current GPL for mustard has been lowered slightly, based on EPA guidelines, to 0.288 mg-min/m^3.

[c] Since no GPL level existed for GF in 1997, we assumed the GB level.

Suspected Releases From Iraqi Unilateral Destruction

As at Al Walid, we note that binary bombs at four other airfields may have been filled with chemical agents when they were unilaterally destroyed by Iraq. In addition, degradation products and a stabilizer of the nerve agent VX were found on some of the fragments of Iraqi warheads for the Al Husayn missile, indicating that a few were filled with VX nerve agent before Iraq destroyed them in the Al Nebai area. If releases occurred, the amounts probably were too low to reach US troops. We include relevant information in appendix M.

Possibility of Additional Chemical Agent Exposure or Release

The existence of additional Gulf war–era releases large enough and close enough to threaten US troops with even low-level contamination is unlikely.

- First, Iraq most likely would have declared damaged chemical munitions—especially those it believed were known to the Coalition from ground destruction in the Kuwait Theater of Operations—because it was accountable for these otherwise useless chemical munitions under the terms of UN resolutions calling for the destruction of Iraq's weapons of mass destruction. UNSCOM indicated that, in the early postwar period, Iraq even provided pieces of damaged munitions in the hopes they would be counted.
- UNSCOM has indicated, and we agree, that Iraq's most recent declaration on munitions filled for the Gulf war—corroborated by independent sources—is fairly accurate, giving us additional confidence that an undeclared large release of chemical agent is unlikely.[12] As shown in appendix D, Iraq's declared chemical weapons deployment locations were located where small chemical agent releases would not reach US troops.
- Iraq declared—and UNSCOM corroborates—that no Iraqi bulk chemical agent storage container was damaged. Most were buried at a safe distance from expected Coalition bombing targets.
- On the basis of UNSCOM information we assess that no significant releases occurred from the bombing of chemical agent production, filling, or research facilities. Iraq had shut down production and filling operations prior to the expected Coalition air attacks.

As the number of newly discovered small releases in table 1 indicate, it is possible there were additional small releases, though these would be unlikely to be an exposure threat to US troops.

- Although we deem it unlikely on the basis of existing information, Iraq could be withholding information on Coalition destruction of advanced weapons—such as VX-filled munitions—to hide that capability.
- Small releases of chemical agents could have resulted from aerial bombing damage to incompletely cleaned chemical equipment in production and filling buildings or chemical agent samples at research laboratories at Al Muthanna. The distance of this facility from US troops would make subsequent chemical exposure unlikely.

Chemical Agent Use

We continue to conclude that Iraq did not use chemical weapons against Coalition forces. In our review of intelligence reporting and analysis of Iraq's chemical agent stockpiles, we found no credible evidence of such use, and we were unable to corroborate any of the reported allegations of CW use in the Desert Storm time frame. On the basis of information on Iraqi Al Husayn (modified Scud) missile warheads recovered from both Saudi Arabia and Israel, we assess Iraq did not employ CW agents in warheads for Iraqi-modified Scud missiles. We believe no chemical bombs were used because Iraq was unable to attack Coalition troops with aircraft. The greatest potential threat was from chemical artillery shells and rockets because Iraqi units had the ability to fire these throughout the war and because these weapons had been stored at several locations south of Baghdad; even so, we do not believe these weapons were used, either. Intelligence information and UNSCOM accounting indicate that Iraqi 155-mm mustard shells were not moved to artillery units for use at the time of the ground war and about 13,000 shells remained at their storage areas near Khamisiyah and at Ukhaydir.[13] In fact, Iraq claims—and intelligence corroborates—that during Desert Storm its troops moved thousands of 155-mm mustard shells and 122-mm nerve agent rockets out of bunkers and into the open to avoid contamination of their troops resulting from chemical weapon destruction by Coalition bombing.

Analysis of Iraq's intentions and motivations also argues against CW use. Coalition member countries made numerous warnings that dire consequences would result from an Iraqi CW attack. Saddam Husayn most likely sought to avoid giving the Coalition an excuse to remove him from power. As a result, he probably ordered his troops not to use chemical weapons—at least not unless it appeared that the regime was threatened. In addition, given Iraq's propensity to store munitions en masse in or near large rear depots for operational control reasons—along with a reluctance to risk overwhelming retaliation to achieve only minimal benefits—it is unlikely that there would have been small, scattered stocks of chemical weapons. The rapidity of the Coalition ground campaign and Coalition air superiority probably contributed to Iraq's decision not to use chemical weapons.

We also assess that Iraq did not use CW agents against Shiites in southern Iraq following Desert Storm. This issue was a concern in a GWI context because of the possibility of downwind exposure to nearby US troops. We assess that the reports of such use are more likely attributable to tear gas or white phosphorus use. According to the DoD close-out report "Possible Post-War Use of Chemical Warfare Agents Against Civilians by Iraq," none of the more than 100 frontline medical personnel interviewed saw or treated any individual they believed was a chemical agent casualty—even though large numbers of Iraqis sought medical help from Coalition units. There also have been allegations of Iraqi use of acids to suppress uprisings, but the IC has not been able to confirm this. It is not uncommon for tear gas, white phosphorus, or military smokes to be confused with acids or chemical warfare agents, particularly by civilians. Finally, we doubt that Iraq would have risked using chemical agents at that time in an area where casualties could be discovered by the Coalition and cause world condemnation.

Coalition Reports of CW

On numerous occasions, Coalition troops reported detection of or exposure to CW agents during military operations in the Persian Gulf. Although some DoD investigations are incomplete, thus far the Intelligence Community does not link any of these reports to chemical agents or weapons. On the contrary, we assess these reports were the result of false alarms, conventional munitions, other chemicals such as missile propellants, and other factors (see appendix N). We continue to follow DoD research on relevant troop reporting.

Of note, we have recently revised our assessment on two well-known Coalition events—Czech CW detections in January 1991 and the blistering of a US soldier in March 1991—that the IC previously deemed to be credible CW events (see appendix N).

Czech Nerve and Mustard Agent Detections

We assess that the Czech detections in question were unlikely to be from a chemical agent. New information and analyses indicate there is no chemical-agent source corresponding to the detections; moreover, there are other more likely causes associated with constraints of the Czech detection system. Although the IC and DoD originally discounted the Czechs' Desert Storm–era reports, the IC has been studying these chemical-agent detections since a Defense Intelligence Agency (DIA)–sponsored team met with Czech Government officials in October 1993. This delegation was provided details of two detections—the detection of airborne nerve agent on 19 January and a mustard puddle on 24 January 1991. Largely on the basis of the Czech procedures and detectors used, the IC and DoD subsequently assessed these were credible chemical-agent detections—though unconfirmed by US detections—but we were unable to identify the source of the chemical agents for either detection. However, new information and analyses indicate chemical agents were not likely to have been the cause of what are now assessed to be at least four Czech detections.

- Our extensive investigations into possible sources of chemical agents failed to identify a plausible chemical-agent source for any of the three nerve agent or one mustard agent Czech detections. Known Iraqi releases do not correspond to the detections and it is very unlikely we missed an Iraqi release, much less, four of the size required to cause the detections in Saudi Arabia. A non-Iraqi chemical agent source is also unlikely.
- New information indicates the Czech detections were not as foolproof as previously believed,[14] leading us to assess that the detections more likely resulted from other causes associated with detection equipment design and operational constraints or defects. For example, Czech officials recently have inferred that buffers in a nerve agent system could have degraded. Buffers are required for the proper operation of the detector and their deterioration might have triggered inaccurate results.

Blisters Suffered by Soldier on Iraq-Kuwait Border

On the basis of new analysis, we now assess that mustard agent did not cause the injuries suffered by a soldier on 2 March 1991.

- Our detailed analysis of associated Fox CW vehicle sensor spectra and other data demonstrates that the Fox equipment detected only large amounts of contamination by chemicals unrelated to mustard. In particular, critical portions of mustard spectra were missing from the Fox spectra.
- Much more sensitive and detailed laboratory testing of the soldier's flak jacket and other items of clothing was negative for mustard and associated degradation products.
- As indicated after the war by the doctor making the field evaluation, other chemicals could have caused the soldier's blisters. We note there are thousands of different blister-causing chemicals, many of which can cause delayed blisters.
- Given what we know about Iraqi CW artillery deployments—large numbers of chemical rockets and shells deployed to established rear depots—we conclude that the storage area searched by the soldier was an unlikely location for CW agents. The storage area in question was constructed for the Gulf war and could not be related to Iran-Iraq war era chemical munitions—as the evaluating doctor originally speculated.

Intelligence on Other Possible Causes of Gulf War Illnesses

In addition to our studies of Iraq's WMD programs, we examined intelligence information for other potential causes of Gulf war illnesses such as regional diseases, industrial toxins, and toxic aspects of conventional weapons. We found no convincing intelligence indicating any other cause, but information is limited. Available intelligence on Middle East regional illnesses does not parallel illnesses suffered by US veterans,[15] including illnesses in southern Iraq that Iraqi propaganda has tied to depleted uranium. We will forward any new potentially relevant reporting to DoD investigators if it becomes available.

Appendix A

Iraqi Chemical Agents and Their Effects

IC research has attempted to identify all chemical agents in Iraq's arsenal during Desert Storm—including those that might have been available only in trace amounts. Such data help to bound the range of toxic agents to which US troops could have been exposed either deliberately or inadvertently. On the basis of UNSCOM and other information, we have compiled a list of confirmed or potential Iraqi chemical agents divided into three categories: Iraq's standard chemical agents, which were present in large quantities in its deployed arsenal at the beginning of 1991; secondary chemical agents found in Iraq in limited quantities, either mixed deliberately with standard agents, present as impurities in standard agents, or present as residual discontinued agent; and miscellaneous chemical agents not believed to be present in significant quantities but which had been researched by Iraq or reported in intelligence channels to have been in Iraq's CW inventory at one time. The results are presented in tables 2 through 4; more detailed descriptions of agent classes and their effects can be found following the tables. On the basis of UNSCOM and intelligence information, it is unlikely that Iraq produced, imported, or deployed for the Gulf war significant quantities of chemical agents other than those shown in table 2.

We have found no credible evidence that Iraq deployed any exotic chemical agents or agents developed to cause long-term illnesses. Iraq produced and weaponized four traditional chemical agents—mustard, sarin, cyclosarin, and the riot control agent CS—in large quantities prior to the Gulf war. In addition, Iraq probably had a small inventory of VX weapons—as indicated by UNSCOM fragment analysis data—and had degraded tabun agent left from the mid-1980s when it was abandoned in favor of sarin. Although Iraq researched the majority of well-known chemical agents, it is unlikely that any other agents were deployed by Iraq. We will continue to look for any new information on such agents in Iraq's inventory.

The UN's information on CW agent R&D and production covers primarily those activities that occurred at the Al Muthanna State Establishment, the organization encompassing the Al Muthanna and three Fallujah facilities. We know less about the production of small amounts of chemical agents for covert use by Iraq's Special Security Organization, based at Salman Pak. However, the chemical agent produced at Salman Pak was meant for assassination, terrorist, and other focused uses and most likely constitutes kilogram quantities or less of any agents.

Detailed research on the connection between nerve agents and Gulf war illnesses is ongoing in the medical community. Low-level exposure to Iraq's deployed chemical agents is not usually associated with the most common long-term symptoms associated with Gulf war illnesses (GWI).[16]

Iraq's Pre-Gulf War CW Program

Prior to the Gulf war, we assessed that Iraq had the largest CW program in the developing world. A large body of information indicated Iraq had produced mustard and nerve agents and used them to fill bombs, artillery shells and rockets, and ballistic missile warheads. Although it began its CW program in the 1970s, Iraq did not begin producing sizable quantities of CW agents until the early 1980s. The Iraqis were producing large quantities of the blister agent sulfur mustard by early 1983 and the nerve agent tabun by 1984. The United Nations Special Commission (UNSCOM) reported publicly that Iraq produced nearly 4,000 tons of CW agents prior to 1991. IC estimates from the late 1980s through 1991, credited Iraq with a production capability of about 1,000 tons per year each of blister and nerve agents.

Iraq had extensive experience in the use of chemical weapons and riot control agents. It used the latter against Kurdish insurgents as early as the mid-1970s. Once the Iran-Iraq war was under way, Baghdad used lethal chemical weapons on a scale not seen in decades. Iraq began using riot control agents against Iranian troops on a large scale in 1982 and blister agents in 1983. It began using the more toxic nerve agents against Iran in March 1984, thereby becoming the first country known to have used nerve agents on the battlefield. CW attacks against Iran increased until the conclusion of the Iran-Iraq war in 1988. In addition, Iraq used both CW and riot control agents against its own Kurdish population on several occasions during this time frame, including the infamous March 1988 attack on Halabja in which press reports claim 5,000 civilians died. UNSCOM has indicated that nearly 3,000 tons of Iraqi CW agents were "consumed"—that is, used in battle—from 1981 to 1988. Iraq used more than 100 tons of CW agents in some individual battles, according to intelligence estimates.

Chemical Agents of GWI Concern

Below we include additional information on several chemical agents or agent mixtures that warrant a more detailed discussion due to previously claimed connections with Gulf war illnesses:

Agent 15. We assess that Iraq never went beyond research with Agent 15—a hallucinogenic chemical similar to BZ—or any other psychochemical. Agent 15 became an issue after a 9 February 1998 British press release claimed that the UK had information, thought to be reliable, that Iraq had large quantities of this chemical agent in the 1980s. UNSCOM and intelligence information indicated that Iraq researched a number of psychochemicals, including Agent 15, BZ, and PCP; however, UNSCOM indicated it saw no evidence of Iraqi importation of large quantities, weaponization, procurement of militarily significant quantities of precursors, or industrial production of these agents.

Mixed Agents. Although Iraq indicated that it researched mixtures of many different chemical agents and even mixed chemical and biological agents, it probably never produced large quantities of mixed agents except for GB/GF nerve agent mixture. UNSCOM information indicates Iraq investigated the following mixtures—mostly different "G" nerve agents—from 1987 to 1989.

- GB and GF
- GB and isobutyl GB
- GB and "GS" (sec-butyl GB)
- GB and isopentyl GB
- isopentyl GB and GF
- GS and GF
- CS (tear gas) and aflatoxin
- Mustard and tricothecene mycotoxins

We assess that mixing GB and GF does not significantly enhance their toxicity. UNSCOM information indicated that Iraq

mixed GF with GB to enhance its persistency and evaporative characteristics in the hot Middle Eastern climate.

Dusty Agents. It is unlikely that Iraq had dusty agents—that is, liquid agents adsorbed onto finely ground silica or another solid carrier—in its inventory during the Gulf war. Iraq did produce and use dusty mustard in the early 1980s on an experimental basis until its successful production of G-series nerve agents. UNSCOM information shows no research or production of dusty agents in the years prior to the war, although a handwritten note found by UNSCOM indicated that an Iraqi was considering the idea in the late 1980s. UNSCOM tested a DB-2 bomb in 1997 because of concern it was filled with dusty sarin, but found only that it had been incompletely decontaminated and that solids had formed from reaction of the bomb's metal casing with an impure sarin mixture.

CW Agent Classes

Blister Agents. Blister agents, or "vesicants," primarily effect the eyes and lungs and blister the skin. The mustard agents are the most common members of this group. Most blister agents are insidious in action; there is little or no pain at the time of exposure except with lewisite and phosgene oxime, which cause immediate pain or irritation on contact.

Blood Agents. Blood agents typically are absorbed into the body by breathing. They prevent the normal utilization of oxygen by the cells and cause rapid damage to body tissues. Blood agents such as hydrogen cyanide (AC) and cyanogen chloride (CK) are highly volatile and in the gaseous state dissipate rapidly in air. Because of their high volatility, these agents are most effective when surprise can be achieved against troops who do not have masks or who are poorly trained in mask discipline. In addition, blood agents are ideally suited for use on terrain that the user hopes to occupy within a short time. Blood agents rapidly degrade a respirator filter's effectiveness. Therefore, these agents could also be used to defeat the protective capabilities of a mask's filter when combined with other agents.

Choking Agents. Choking agents are the oldest CW agents. This class of agents includes chlorine and phosgene, both of which were used in World War I. In sufficient concentrations, their corrosive effect on the respiratory system results in pulmonary edema, filling the lungs with fluid and choking the victim.

These agents typically are heavy gases that remain near ground level and tend to fill depressions such as foxholes and trenches. Because they are gases, they are nonpersistent and dissipate rapidly, even in a slight breeze. As a result, these are among the least effective traditional CW agents. They are useful for creating a short-term respiratory hazard on terrain that is to be quickly occupied.

Nerve Agents. Traditional nerve agents, including tabun (GA), sarin (GB), cyclosarin (GF), and VX, are members of a class of compounds that are more lethal and rapid acting than mustard. They typically are organophosphorus compounds that inhibit action of the enzyme cholinesterase. In sufficient concentration, the ultimate effect of these agents is paralysis of the respiratory musculature and death.

Nerve agents typically act rapidly (within seconds of exposure) and may be absorbed through the skin or through the respiratory tract. Exposure to a lethal dose may cause death in less than 15 minutes. They are stored in munitions as liquids and are generally disseminated as aerosols.

Traditional nerve agents fall into two main classes: G-series and V-series. The G-series consists of GA, GB, GD, GE, GF, and a number of similar experimental agents. These agents, particularly GA and GB, tend to be less persistent than their V-series counterparts and present less of a skin hazard. These G-series agents are used to cause immediate casualties and to create a short-term respiratory hazard on the battlefield. The more persistent and generally more toxic V-agents, including VE, VG, VM, VS, VX, and related experimental agents, present a greater skin hazard and are used to contaminate territory.

Psychochemicals. Psychochemicals, also considered incapacitants, include hallucinogenic compounds such as lysergic acid diethylamide (LSD), 3-quinuclidinyl benzilate (BZ), and benactyzine. These agents alter the nervous system, thereby

causing visual and aural hallucinations, a sense of unreality, and changes in the thought processes and behavior. Psychochemicals are generally characterized by a slightly delayed onset of symptoms and by persistence of symptoms for a period greatly exceeding exposure time.

The advantage of psychochemicals is their ability to incapacitate both civilian and military personnel for a relatively short period with essentially no fatalities. Thus, their use may prove advantageous in areas with friendly populations. One drawback, however, is that the effects of many of these agents are unpredictable, ranging from overwhelming fear and panic to extreme belligerence in which exposed personnel attack with little regard for personal safety.

Tear Agents. Tear agents fall under the broader category of riot control agents. They are not considered by the US Government to be CW agents because they are non-lethal in all but the highest concentrations. Examples of this type of agent include orthochlorobenzylidene malononitrile (CS), chloroacetophenone (CN), chloropicrin (PS), and bromobenzyl cyanide (BBC). These agents are highly irritating, particularly to the eyes and respiratory tract, and cause extreme discomfort. Symptoms occur almost immediately on exposure and generally disappear shortly after exposure ceases.

In military situations, tear agents are used to temporarily reduce the effectiveness of enemy personnel. In tactical operations, they can be used to penetrate fortified positions and flush out the enemy. Also, these agents are useful for disrupting unprotected “human wave” assaults by breaking up formations and destroying the momentum of the attack. Because tear agents are not harmful in normal battlefield concentrations, they can be used near friendly troops without risking casualties; thus, their use is more flexible than with conventional CW agents.

Vomiting Agents. Vomiting agents are often considered to be riot control agents because, under field conditions, they cause great discomfort but rarely serious injury or death. Characteristic agents include adamsite (DM) and diphenyl chloroarsine (DA). In addition to causing vomiting, these arsenic-based agents may also irritate the eyes and respiratory system.

The action of vomiting agents may make it impossible to put on, or continue wearing, a protective mask. Therefore, in military situations, vomiting agents may be used in conjunction with lethal CW agents to increase casualties. They may also be used in proximity to friendly troops and in other situations well suited for tear agents.

Appendix B

Iraqi Chemical Munitions and Bulk Storage Containers

At the time of Desert Storm, Iraq possessed a chemical stockpile consisting of aerial bombs, Al Husayn missile warheads, artillery shells, and artillery rockets (see table 5 and figure 3, figure 4, figure 5, figure 6, figure 7, and figure 8). The Iraqis also possessed mortar rounds and grenades filled with the riot control agent CS.[17] We have not identified any credible evidence that the CS-associated mortar rounds and grenades were fielded with any agent fill other than CS at the time of the Gulf war.

Iraq declared it tested a wide variety of chemical munitions for military potential (see table 6), but it produced and fielded only a few types of chemical weapons—selected for favorable performance. The weapons tests encompassed various structural aspects of the munitions, the flight dynamics of filled munitions, and agent dispersal capabilities. Payloads ranged from generic oils, simulants, and water to actual chemical agents. In addition, some munitions were filled with chemical agents to test chemical agent stability and corrosive effects on the munitions in storage.

Although there is still a slight possibility that Iraq has hidden its development or production of certain munitions or munition fills, its declaration of chemical munitions filled and tested is mostly consistent with UNSCOM and US information. Even so, we cannot rule out that Iraq might have produced sophisticated chemical weapons, such as binary artillery shells, cluster bombs, and VX-filled munitions.

Munitions of GWI Concern

Although there have been allegations that Coalition troops were exposed to CW agents from land mines, grenades, rocket-propelled grenades, Styx and Silkworm missiles, and unmanned aerodynamic vehicles, we conclude that it is very unlikely these were in Iraq's CW inventory. Extensive UNSCOM inspections of tens of thousands of chemical munitions at chemical weapons storage, production, and filling facilities such as Al Muthanna and Muhammadiyat—which included the discovery of a munitions museum at Al Muthanna in January 1996—showed no physical evidence of such munitions. Similarly, according to UNSCOM, these munitions are not included in any of the thousands of pages of documents turned over by Iraq or excavated from the rubble at the Al Muthanna production facility. Such munitions also were not discovered during Iranian-sponsored investigations of munitions during the Iran-Iraq war or by international groups clearing Kuwait of unexploded ordnance after the Gulf war. Iraq would be less likely to deploy many of these weapons because they have limited utility due to handling, control, and fratricide concerns.

Chemical Munitions Markings

Iraq appears to have used CW-specific markings on its chemical munitions only in rare cases. Iraq claims no uniform chemical munitions marking system and that personnel from the Al Muthanna State Establishment accompanied chemical munitions until they were used. UNSCOM found that, except for the Al Husayn warhead and 155-mm shells (see figure 8 and figure 9), munitions had no CW-specific markings (see table 8).

UNSCOM assessed that chemical artillery munition crates also had labels, usually one per lot, identifying production information about that lot, including type of munition, number in lot, data on chemical agent fill, etc. UNSCOM believes that at a distance these labels would be indistinguishable from labels seen on conventional munitions crates. UNSCOM knows of the existence of these labels through discussions with Iraq but has never seen them. The Iraqis may have removed the labels prior to inspections to hide production information. US troops did not report finding such labels at Khamisiyah.

Bulk Storage

Table 8 provides UNSCOM information on the chemical agent storage containers used by Iraq. Photos of some of these containers are shown in figure 10, figure 11, and figure 12. Although there is intelligence information that Iraq dropped 55-gallon drums filled with chemical agent from helicopters early in the Iran-Iraq war, UNSCOM did not find chemical agents in such containers.

Iraq has indicated that at the time of Desert Storm bulk chemical agent was stored at Al Muthanna although it had used two other facilities previously. UNSCOM confirmed that it found undamaged bulk chemical agent containers at the Al Muthanna facility. Tens of metric tons of mustard, sarin/cyclosarin, and degraded tabun were found at Al Muthanna in large buried containers or in pits just inside the fence line containing multiple containers (see figure 12 and figure 13). Iraq also indicated that bulk CW agent storage occurred at the Ukhaydir ammunition storage depot during the Iran-Iraq war, but we assess this occurred prior to the completion of storage facility at Al Muthanna. Iraq could have also used Muhammadiyat for bulk storage prior to Desert Storm because this site was Al Muthanna's alternate storage facility for filled munitions. No evidence of bulk storage was discovered during UNSCOM inspections at either Ukhaydir or Muhammadiyat.

Appendix C

Chemical Agent Releases

On the basis of estimates of release amounts, computer modeling, and distance from US troops, we assess that only the Khamisiyah Pit release probably exposed US troops[18] to low levels of chemical agents. This minimal exposure can be attributed to several factors:

- ***Most chemical munitions were missed by Coalition aerial bombing***. Iraq made a significant effort to avoid the destruction of its chemical agents to preserve its military options and to avoid contaminating its own troops and civilians. Iraq's efforts included storage of chemical weapons in the open and in standard bunkers, dispersal from the main CW facility at Al Muthanna, and open burial of bulk agent storage containers. As a result, only about 8 percent of the over 700 tons of chemical agent and chemicals UNSCOM found in chemical weapons or bulk containers was released as a result of Coalition bombing.
- ***Low nerve agent purity***. Although Iraqi mustard agent was relatively pure, Iraq's more toxic nerve agents were only about 60 percent pure when produced and rapidly degraded such that, by the time of release, the purity varied from 50 percent to less than 15 percent.
- ***Less toxic binary munitions***. Most of Iraq's Gulf war–era nerve agent was kept in binary form. Iraqi binary munitions contained only relatively nontoxic alcohols into which a second chemical would have to be manually added before forming toxic nerve agents within the munition.
- ***Chemical agent neutralization and burning***. Only a small proportion of the chemical agent released from Iraqi munitions damaged by Coalition action actually entered the atmosphere. Laboratory testing indicates roughly half of the agent released from damaged munitions is retained by, or neutralized in, crates and soil. Chemical agents subjected to fire will burn or otherwise break down—causing anywhere from 95 to more than 99 percent of the agent to degrade, according to field tests and computer modeling.[19]
- ***Dispersion and environmental degradation***. The great distance of most storage locations from US troops allowed significant time for the chemical agent to disperse and degrade in the environment.
- ***Winds were not always blowing toward US troops***. Chemical agents are carried by winds, and during the Gulf war, the prevailing wind blew from the south, east, or west—generally away from US troops—as often as it did toward troops. For example, the Khamisiyah Bunker 73 release did not expose US troops—some only several kilometers away at the time—because winds were blowing from the southwest away from troop locations.

As indicated by table 9,[20] the releases of chemical agent from the unmodeled events—highlighted in red italics—are assessed not to have reached US troops based on the modeled events. Completed modeling covers a wide variety of weather conditions, especially for events such as Muhammadiyat, which included multiple dates and times covering almost the whole air war because the specific attack causing the release was unknown. In addition, modeling performed since 1997 has included multiple weather and dispersion models. The worst case of these models—which included significant expansion of the hazard area to account for some wind uncertainties—was examined to determine an upper bound on downrange general population limit (GPL) level contamination for varying amounts of nerve and mustard agent.[21] Based on this upper bound, the maximum downrange GPL contamination for the estimated amount of chemical agents released by unmodeled events falls short of US troops in Saudi Arabia.[22]

Modeling of Environmental GB/GF Nerve Agent Decay

On the basis of research by a CIA contractor, it is now possible to confidently include daytime degradation of GB/GF nerve agent in models. Almost immediately after release, nerve agents begin to degrade by reacting with atmospheric constituents. However, the degradation mechanism is different during the day and night. During the day, sunlight reacts with the atmosphere to produce hydroxyl ions that react to break down nerve agents. During the night, degradation is a function of

the amount of nitrate radicals in the atmosphere that are in turn a function of pollution levels from the burning of fossil fuels. In 1997, CIA and DoD chose not to include atmospheric degradation in order to be conservative and because there was no accepted way to model its intensity. Subsequently, CIA's contractor was able to establish reasonable minimum daytime decay rates for use in future modeling. Modeling of nighttime degradation is still considered too difficult at this time because of unknowns about nitrate levels in Iraqi air.

Appendix D

CW Storage Sites

One major element of our investigation into possible CW exposures was a concerted effort to locate and account for Iraq's wartime chemical weapons stockpile—an issue that has been the subject of much debate and confusion. Recognizing this as a difficult task, we examined Iraqi storage and deployment practices and carefully scrutinized historical intelligence reporting in an effort to identify all Iraqi chemical weapons storage locations during the Gulf war.

Iraq's Chemical Munition Storage Declaration Largely Corroborated

Early Iraqi declarations were incomplete and deceptive—especially regarding binary-nerve-agent munitions[23]—but have become more accurate over time, probably as a result of UNSCOM monitoring efforts (aided by information about Iraq from other UN members) and Iraq's desire to be released from sanctions. On the basis of UNSCOM inspections and intelligence information, we assess that Iraq's latest declaration of its wartime storage locations (see table 10 and figure 14)—especially artillery munitions sites—is fairly accurate. For example, the dispersal of 155-mm mustard shells to Ukhaydir, An Nasiriyah, and Khamisiyah is corroborated by intelligence and UNSCOM inspector observations. We believe Iraq was largely cooperative on its latest declarations because many of its residual munitions were of little use—other than bolstering the credibility of Iraq's declaration—because of chemical agent degradation and leakage problems. Nevertheless, insufficient information is available to corroborate some munitions deployments and the completeness of Iraq's declaration.[24]

Additional Storage Sites in the Kuwait Theater of Operations (KTO) Unlikely

After reviewing UNSCOM information and intelligence reporting, we conclude it is unlikely that Iraqi chemical weapons were stored during Desert Storm at any location in the KTO other than Khamisiyah and An Nasiriyah.[25] Chemical munitions were destroyed by US ground troops only at the Khamisiyah site because Iraq probably had moved the An Nasiriyah munitions to Khamisiyah in mid-February. Our assessments are based on several factors:

- Intelligence information corroborates Iraqi accounts that artillery munitions[26] at Khamisiyah and 155-mm shells at Ukhaydir were not further deployed for battle and, in fact, were stored in the open to preserve them from destruction. Had Iraq attempted to deploy these 12,500+[27] openly stored munitions to operational units, we would have expected the number of shells in storage to decrease considerably—which did not happen.
- The few unaccounted Iraqi shells are unlikely to have been in the KTO. Although Iraq has declared that 550 155-mm shells were destroyed by Coalition action, we assess this declaration to be false. Iraq first indicated these shells were destroyed by Coalition bombing at Muhammadiyat and most recently claimed they were destroyed by Shiite rebels well north of the KTO. We assess as more likely previous Iraqi explanations that these shells were a separate lot, not deployed southward.[28]
- Multinational teams that cleared Kuwait of unexploded ordnance found no chemical munitions among the hundreds

of thousands destroyed, even though there was significant monetary incentive to do so. Mustard shells would have been more likely to be noticed because they often were marked and their destruction would have caused a noticeable longer term hazard (See appendix B, table 8).

Other Reports of CW Sites

Although we cannot prove a negative, we assess the vast majority of the sites listed in intelligence, military, and other reporting are unlikely to have stored chemical agent or weapons during the Gulf war and even less likely to have released chemical agents. So far we have not found any site, other than those eventually declared to UNSCOM, where Iraq stored chemical weapons during the war. After reviewing intelligence and military information, we counted over 200 sites—including the 21 storage sites declared by Iraq—allegedly linked to chemical weapons around the time of Desert Storm. The undeclared sites were compiled from a number of different sources.

Intelligence Information on Storage. The vast majority of assessments and raw reporting—unevaluated human source information—on sites containing chemical weapons was inaccurate.[29]

- Intelligence assessments that munitions would be in previously identified special bunkers were shown by UNSCOM inspections and retrospective intelligence studies to be mostly in error. UNSCOM and US troop inspections showed no chemical weapons in these bunkers[30] and instead revealed that Iraq used these bunkers for conventional weapons. Iraq tended to store chemical munitions in the open, as at Muhammadiyat and Ukhaydir, or in conventional bunkers such as Bunker 73 at Khamisiyah.
- Raw intelligence is often inaccurate. This problem was exacerbated during Desert Shield/Desert Storm when the reporting threshold was lowered to ensure that any potentially relevant information was provided to military planners. As a result, intelligence channels were flooded with low-grade information that often amounted to simply rumors. A review of this body of information showed that many sources were not knowledgeable about the technical issues on which they were reporting. For example, some sources mistook the presence or use of gas masks as an unmistakable indicator of chemical warfare agents, when in fact masks often are worn when handling certain non-CW military chemicals such as propellants for tactical missiles. Furthermore, many sources assumed that certain munitions were chemical weapons merely because the munitions bore unusual or unfamiliar markings.
- Sites with V-shaped chemical decontamination trenches, thought by some to have been indicators of chemical weapons storage, are now believed to have been related to standard chemical defenses and as a contingency for offensive chemical use.

Military Reporting of CW Sites. We reviewed firsthand accounts of chemical weapons from Coalition troops in conjunction with associated DoD and independent analyses but could not find any credible evidence that chemical weapons were stored elsewhere in the KTO. We conclude that many CW allegations resulted from unfamiliarity with CW agents or Iraqi chemical munitions. For example, inhibited red fuming nitric acid leaking from a chemical tank in Kuwait was confused for mustard agent, even though the contents had characteristics clearly inconsistent with mustard. In other cases, yellow-tipped anti-armor tank shells were thought to be mustard shells because of the unusual colored markings. DoD lists—such as the "ARCENT list" of 17 suspected CBW sites—were produced as an analytic assessment and lacked reliable information connecting them to chemical storage (see paper *17 Suspect CW/BW Storage Sites Identified in 28 February 1991 CENTCOM Message, 29-30 July 1997*).

Appendix E

Khamisiyah Pit Nerve Agent Release

In mid-1996—after CIA determined that US soldiers inadvertently destroyed chemical rockets at Bunker 73 at the Khamisiyah Ammunition Storage Area—it was learned that US soldiers also inadvertently destroyed nerve-agent-filled rockets in a pit area two kilometers to the south (see figure 2). An intense Intelligence Community-DoD analytic and modeling effort—including DoD field tests using replica rockets filled with nerve agent simulant—resulted in a determination in 1997 that nearly 100,000 US troops were in computer-model-derived areas of potential exposure to low-levels of chemical agent from the release. The results of these analyses are contained in the publication *Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit*, 4 September 1997.

We conclude that there was a definite release of nerve agent from the Khamisiyah Pit on the basis of troop statements and the following evidence:

- DoD, intelligence, and other information indicate US troops damaged stacks of intact rockets at the identical location where UNSCOM later found damaged nerve-agent-filled rockets (see figure 15 and figure 16). UNSCOM confirmed by sampling that the rockets contained a mixture of GB and GF nerve agents (see figure 17).
- Photos taken by US soldiers at the site within days of the destruction showed the rockets and rocket crates—with features identical to known chemical rockets (see figure 18).

We also conclude that at least some US troops probably were exposed at low levels because:

- US forces were in proximity, some only several kilometers away.
- Soot trails, weather modeling predictions, and soldier reporting, all indicate that the winds at the time of demolition were blowing southerly, toward US troop locations.
- Even using the model tending toward shortest dispersion and assuming the smallest release, the contamination would go tens of kilometers at low exposure levels.

However, 2001 DoD modeling results indicate the potential exposure area from this release is about half that published in July 1997 and in the 4 September 1997 CIA/DoD Khamisiyah Pit modeling report. Updated estimates of the quantity of agent released, better and additional modeling parameters, and DoD's new low-level-exposure threshold all contributed to a reduction of the 1997 low-level contamination area. The number of US troops potentially exposed remained about the same because of improved DoD troop location information. The actual number of US troops exposed would be a subset of those notified because exposure areas account for some modeling and troop location uncertainty.

Lower Release Amount

As shown in table 11, we have reassessed since 1997 the number of rockets still containing agent and releasing agent. This change is a result of new UNSCOM information that led us to conclude more intact rockets were moved to the Al Muthanna CW Facility than previously assessed (see text on page 48 for more details). A more detailed discussion of the other estimates in the table is included in the September 1997 paper mentioned previously.

Previous Assessment of Rockets Releasing Agent

In 1997, lacking more definitive data, we modeled a chemical agent release from about ***500*** rockets based on two independent estimates.

- Modeling based on small demolition tests at Dugway Proving Ground, Utah, suggested that as many as 500 of the rockets in the pit would have spilled agent. The estimate assumed a worst case situation where the maximum number of reported demolition charges were randomly placed to achieve the most destructive effects—directly on the ends of some rockets after the crate ends were opened.

- UNSCOM accounting indicated a total of about 750 of the 1,250 rockets from the pit were not damaged[31] and subsequently were destroyed by Iraq under UNSCOM supervision. Four hundred twenty-five were destroyed near Khamisiyah during an inspection in February-March 1992 and afterwards 319 were destroyed at Al Muthanna following excavation from the pit embankment.

New Information Motivates Revised Assessment

Following our 1997 assessment, two key pieces of information helped us to conduct a reassessment of damaged munitions.

- In June 1998, an UNSCOM team's thorough search of Khamisiyah—performed to clear the site of rockets still filled with degraded nerve agent—found only a fraction of the rocket fragments expected for 500 rockets assumed to have released agent.[32] Searching with sophisticated ground penetrating radar over a large area, UNSCOM Team 210 found only about 100 "significant pieces" from rockets that probably released agent.
- An interview with the senior explosive ordnance demolition officer at Khamisiyah—who inspected the completed demolition setup—indicated that the placement of charges was less than optimal on some of the stacks because of time constraints. Some of the charges were actually placed on the ends of boxes or the ends of stacks—not directly on the rockets, as the IC modeled—thus greatly lessening the number of rockets damaged.

Revised Calculation of Rockets Retaining Agent After Khamisiyah Demolition

Table 12 summarizes our calculations based on information from UNSCOM indicating that about 225 rockets released agent.[33]

Number of Filled Rockets Destroyed by UNSCOM 29 at Khamisiyah. In February and March 1992, UNSCOM 29 inspectors destroyed 463 rockets of which 38 were empty, leaving 425 agent-filled rockets. We assess that 36 partially filled rockets found by the inspectors leaked because of Iraqi recovery efforts, including bulldozing of rockets.

Number of Filled Rockets Excavated From Khamisiyah and Destroyed at Al Muthanna. At the end of its inspection, UNSCOM 29 discovered that additional chemical rockets were buried in the pit embankment. After 80 filled rockets or rocket warheads had been unearthed with no end in sight, UNSCOM asked Iraq to continue the excavation and move filled rockets to Al Muthanna for destruction. According to UNSCOM, destruction records at Al Muthanna did not record the number of Khamisiyah rockets and 319 was assumed—based on rockets destroyed at Al Muthanna in which the warhead could not be separated from the motor. We calculated our new estimate of 413 rockets by taking the final number of rockets destroyed at Al Muthanna—6,773—and subtracting the 6,360 rockets UNSCOM counted at Al Muthanna prior to the excavation in September 1991.

Number of Filled Rockets Moved From Khamisiyah to Al Muthanna Prior to Khamisiyah Inspections. According to UNSCOM information, Iraqi salvaging of 122-mm rockets prior to UNSCOM field inspections probably included retrieval of about 174 undamaged rockets from Khamisiyah.[34] UNSCOM 17 inspectors subsequently counted 6,360 rockets at Al Muthanna, 200 more than Iraq's declaration of 6,160 rockets moved there from two other deployed sites (see table 10, appendix D). Our final estimate of 174 is the difference between the 200 and the 26 rockets that UNSCOM indicated were found scattered in other areas of Al Muthanna and, thus, probably were miscellaneous shells that were not deployed. As seen in figure 21, many of these rockets may have come from one stack of about 160 rockets that appears to have suffered little or no damage.

Number of Filled Rockets Found By UNSCOM in 1998. A 1998 UNSCOM inspection team unearthed 17 rockets at Khamisiyah that were believed to be full of agent. They were subsequently thermally destroyed at Khamisiyah by Iraq under UNSCOM supervision.

Appendix F

Khamisiyah Bunker 73 Nerve Agent Release

US soldiers inadvertently destroyed nerve-agent-filled rockets in Bunker 73[35] at Khamisiyah on 4 March 1991 (see figure 2, and figure 22). CIA's 1996 analysis and modeling indicated that US troops were not exposed because winds carried any nerve agent in the demolition clouds to the northeast—away from troops. For additional background information, see *CIA Report on Intelligence Related to Gulf War Illnesses,* August 1996, and other reports mentioned in the bibliography.

Moreover, subsequent to our 1996 assessment, new UNSCOM information has greatly reduced our assessment of the amount of agent that would have been released. We now assess that only 51 kg of agent was released from Bunker 73—in contrast to the estimate of 1,060 kg made in 1996. Our assessment of wind direction has not changed. As reported at that time, video, photographic, and weather modeling data indicate the winds were blowing slowly to the northeast, away from US troops and over a swampy area.

Lower Release Amount: The Details

As shown in table 13, a number of factors resulted in our reduced estimate of the mass of nerve agents released:

Number of Rockets in Bunker 73. Our current estimate uses Iraq's declaration of 2,160 rockets at the site (both pit and Bunker 73) and subtracts our best estimate for the number of those rockets in the pit—1,250—yielding 910 rockets in the bunker. The previous estimate was based on Iraq's estimate of 1,100 rockets in the pit.

Number of Rockets Containing Agent After Demolition. In 1998, UNSCOM sent an inspection team, UNSCOM 210, to excavate Bunker 73—previously filled with dirt—to eliminate the continuing CW hazard of remaining Khamisiyah rockets. Total excavation of Bunker 73 by UNSCOM 210 yielded a total of 213 filled chemical rockets, about 20 of which were leaking.[36] Chemical monitoring with CAMs and an FTIR confirmed the rockets were filled with nerve agent. The FTIR indicated limited presence of GB/GF. The 213 agent-filled rockets were explosively destroyed in June 1998.

Our current estimate is based on that inspection and assumes an additional 50 rockets survived the demolition intact but leaked at a later date because of postwar excavation and other disturbances. In 1996, as a worst case we assumed that no rockets contained agent after demolition.

Number of Rockets Releasing Agent. This number is calculated by subtracting the number of rockets still containing agent from the initial number of rockets. Note that we assess that the destruction at the bunker was much more severe than at the pit because of the more extensive use of explosives,[37] evidence of intense fire and other extensive damage, and a significant number of unaccounted rockets.

Weight of Fill of Each Rocket. The 1996 assessment was based on an Iraqi-declared payload weight of 8 kg, which we later determined included the weight of the plastic insert. The correct agent fill weight of the Sakr-18 warhead is 6.3 kg.

Purity of Nerve Agent. In 1996, we had not researched the issue of agent purity and, therefore, assumed a worst case figure of 100 percent purity. Analysis of UNSCOM information now indicates the purity was about 50 percent at the time of the demolition. See "*Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit,*" 4 September 1997, for more details.

Amount of Agent Contained in Releasing Rockets. This number is calculated by multiplying the number of rockets releasing agent by the amount of fill of each rocket and the purity of the agent.

Impact of Long Range Flyouts on Area of Exposure

It is very unlikely that long-range flyouts caused CW agent exposure to US soldiers. Soldiers reported seeing flyouts of munitions during the detonation of more than 30 bunkers at Khamisiyah on 4 March 1991 and of rockets during the Khamisiyah Pit demolition on 10 March. The box on page 12 of Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit, September 1997, contains details of our assessment. This includes the conclusion that flyouts of the Sakr-18 rockets probably did not exceed a range of 4 kilometers, and most probably flew less than 2 kilometers—well short of their maximum range of 18 kilometers when fired from a launcher at an optimal angle. In addition, 1997 testing at Dugway suggests that longer range rockets are more likely to bury themselves in the desert ground than to break open on impact. In fact, UNSCOM 17 photographed a partially buried rocket less than 2 kilometers from the Khamisiyah Pit and Bunker 73 (see figure 23).

Percent of Agent Released. The current estimate of only 2.5 percent of agent released from the bunker fire is considered conservative and is borne out by US testing, evidence of an intense fire uncovered by UNSCOM inspection in 1998, and information on the thermal instability of sarin and other G-agents.

- As in 1996, we assume that 2.5 percent of the agent was released from the bunker because of comparisons with US "Black Hills" testing on sarin-filled rockets in the 1960s. However, on the basis of test information on flyouts (see text box), we no longer assess that an additional 10 percent of the rockets flew out of the bunker and broke open, spilling their agent. Our current 2.5-percent estimate is still considered conservative because agent heating conditions were harsher in bunker 73 than the Black Hills tests. The US tests were performed using simulated bunkers that had earth walls and a ceiling of wood slats and sand, whereas bunker 73 would be expected to heat up more quickly because it had concrete walls and a covering of concrete ceiling debris.
- Since 1997, we have no longer assumed a 100-percent release from rockets flying out of the bunker as was done in 1996. We now assess that rockets ejected from the bunkers are unlikely to have released their agent (see text box on rocket flyouts).
- The UNSCOM 210 inspection showed that the rockets appeared to have been subjected to an intense fire as indicated by the lack of wood from the crates and the lack of unburned propellant. Sarin and cyclosarin start to degrade at temperatures above 150 degrees Celsius with the degradation rate increasing rapidly above 300 degrees Celsius—well below the expected temperatures in a bunker fire fueled by burning rockets (see figure 24).[38]

Total Amount of Agent Released. This value is calculated by multiplying the amount of agent contained in the releasing rockets by the percent of agent released.

Appendix G

Al Muthanna Production/Filling/Storage Facility and Chemical

Agent Releases

This appendix provides significant detail on the Al Muthanna CW facility, which is of interest because it played a central role in Iraq's CW program and, more importantly, was considered a potential cause of chemical alarms in Saudi Arabia. Although Coalition bombing released nerve agent from a large storage bunker and mustard agent from the production facility, we assess these releases were insufficient to reach US troops or to initiate alarms 470 km away.

UNSCOM saw no other areas at Al Muthanna that had indications of a large chemical spill. At various locations at Al Muthanna UNSCOM found munitions and bulk mustard storage containers leaking because of defective seals but these did not cause a significant hazard outside of the facility. We continue to assess that undiscovered large releases of nerve agents from production, filling, and storage facilities are unlikely, though we cannot rule out the release of small amounts of nerve agent from incompletely cleaned equipment in bomb-damaged buildings.

Facility Background and Locations of Releases

Al Muthanna (US name Samarra)—the most important facility under Iraq's Al Muthanna State Establishment CW infrastructure[39]—was Iraq's primary chemical agent production and weapons filling facility prior to 1991. It was begun in the 1970s as a dedicated facility for the CW program. By the time of the Gulf war, Al Muthanna's efforts included research, development, and production of chemical agents, production, filling, and storage of chemical munitions, and—according to Iraq—filling of biological weapons.

Al Muthanna is a large facility divided into multiple areas (see figure 25). All areas except for the administrative area have been assigned letter designators to minimize confusion:

- ***Area A. Chemical Stores and Receiving Area***. Functions of this area included the receipt of chemical precursors and equipment imported from other countries or produced indigenously. Chemical agents were not stored here.
- ***Area B. Research Laboratories and Storage Bunkers***. This area was involved in research, precursor production, and storage of filled munitions prior to deployment. There were no indications of chemical contamination at the labs where we would expect only small amounts of chemical agents to be present. The storage area at Al Muthanna included eight cruciform bunkers (see figure 26) for storage of filled chemical weapons prior to deployment. UNSCOM found significant agent contamination from Coalition bombing in Bunker 2, as discussed below. Although other bunkers were hit, UNSCOM did not find indications of damage to chemical-agent-filled munitions or bulk storage containers contained within. Leaking but otherwise intact one metric ton mustard bulk storage containers were found in another bunker.
- ***Area C: Precursor and Agent Production Area***. Mustard, sarin, cyclosarin, and VX were produced here. UNSCOM found contamination at the mustard production facility (P8), indicating a release. The sarin plant was undamaged. A leaking DB-2 GB/GF-filled bomb was found near the sarin plant. The VX plant was totally destroyed but no contamination was found, suggesting no release. This area was also the location of most of the wartime bulk mustard and nerve agent storage. These bulk containers were buried in pits along the fence line and none were damaged or leaking (see figure 13, page 28).[40]
- ***Area D: Bunkered Production Area***. This area contained multipurpose pilot plants and a bunker for the production of the nerve agents sarin and cyclosarin. The nerve agent plant was damaged but no contamination was noted.
- ***Area E: Munitions Filling Area***. UNSCOM noted no significant contamination in this area, which was completely destroyed by Coalition bombing. The Iraqis claimed no bulk material was stored in this area at the time of the bombing.
- ***Other Areas at Al Muthanna***. Toxic contamination was noted at several of the chemical dumpsites previously established by the Iraqis in the area, but these were not indicative of a large spill of agent. The Iraqis put many leaking munitions in an area dubbed the "graveyard." Many of these were buried to minimize airborne contamination.

Al Muthanna Bunker 2 Nerve Agent Release

UNSCOM inspectors found that a bomb had penetrated Bunker 2 and caused nerve-agent-filled 122-mm rockets inside to burn (see figure 27 and figure 28). In 1996, CIA modeled a worst case release from chemical rockets in Bunker 2 on the basis of Iraq's declarations and worst case assumptions on release and weather. Even with these assumptions, modeling showed that low-level contamination did not reach US troops. Recently published DoD remodeling of this release also indicated that US troops were not exposed. The 1996 analysis is covered in the report *CIA Report on Intelligence Related to Gulf War Illnesses*, August 1996.

The contamination modeled in 1996, which did not reach Saudi Arabia, was based on a CW agent release forty times greater than our current assessment,[41] which is the result of new UNSCOM information—including photos of the site—indicating that Iraq overstated the number of rockets in the bunker and that the chemical agent purity was much lower than previously assumed. Subsequently, a CIA contractor performed detailed modeling of the release, concluding that—because of the extreme heat build-up in the bunker and the thermal instability of sarin—less than 1 kg of agent probably was released. To be conservative, we have assumed a maximum of 10 kg of sarin was released.

On the basis of UNSCOM information, we assess that there were a maximum of 1,500 rockets in the bunker and perhaps as few as 1,000. UNSCOM indicates that the bunker contained various types of defective leaking rockets from the Iran-Iraq war era. This is consistent with Iraq's known effort before the Gulf war to move viable munitions away from the not-so-secret Al Muthanna[42] and nearer to possible deployment areas. According to UNSCOM, Iraq indicates that no more than 500 of these rockets were Sakr-30s as opposed to the previous declaration of 2,500 damaged Sakr-30 rockets. UNSCOM inspection information corroborated Iraq's declaration about multiple types of chemical rockets and also indicated conventional rockets were in the bunker.

UNSCOM indicates that during the Iran-Iraq war Iraqi rockets were filled with sarin, as opposed to a sarin/cyclosarin mix, and that the highest purity UNSCOM found on any agent of that era was 18 percent. As a worst case we chose this value of purity although it is very likely that the purity was much less.

Details of our analysis of rocket numbers and purity are contained in a 17 February 1999 CIA memorandum to DoD that forms part of the foundation for DoD's 2001 Case Narrative. Table 14 provides a comparison of current and 1996 assessments of release parameters.

Our assessment that more than 99 percent of the agent was destroyed in the bunker fire is based on detailed modeling performed by CIA contractors. They assessed that far less agent (a maximum of 0.01 percent) would have been released in the Al Muthanna bunker incident than the 2.5 percent indicated by 1960s US field tests at Black Hills, South Dakota. The Black Hills tests used simulated bunkers that had a wood slat, sand ceiling, and earth walls. Those bunkers did not allow heat to build up as rapidly as in an Iraqi bunker with thick reinforced concrete ceiling and walls. However, we have chosen 10 kilograms as the release amount to account for unmodeled releases from rocket flyouts or transients at the beginning of the fire.

Mustard Production Facility Release

We now assess that a mustard release from the bombing of the mustard production facility (see figure 29) at Al Muthanna is likely, but that additional large releases from production or filling areas are unlikely. Previous CIA assessments indicated that agents were released only from munitions stored in Bunker 2 and not from any of the production areas. On the basis of discussions with UNSCOM, we assessed—as indicated in our August 1996 *CIA Report on Intelligence Related to Gulf War Illnesses*–that "all known CW and precursor production lines were either inactive or had been dismantled by the start of the air campaign." Since we published that assessment, UNSCOM more thoroughly investigated the possibility of releases and discovered low-level mustard contamination at the destroyed mustard production plant—indicative of a mustard release.

After discussions with UNSCOM, we assess there was a slow release of no more than about 2 tons of mustard. The release probably was very slow because the agent was under the rubble of the production building and, therefore, protected from winds and heating that would speed evaporation. UNSCOM indicated that, based on the levels of contamination, the amount of spilled agent probably was less than a ton and no greater than 2 tons. Although mustard from the production building was stored in large (20 m3) containers, Iraq indicated that it made significant efforts to close down production to minimize contamination. We assess that the release might have been the result of leakage from a temporary holding tank or "slop tank" whose capacity would have been far less than that of the large storage tanks.

Low Likelihood of Additional Significant Releases

We assess that additional large releases from production, storage, and filling facilities at Al Muthanna are unlikely:

- Release of CW agent from bomb damage to bulk storage containers is unlikely because of the dispersal and burial of the vast majority of storage tanks away from buildings (see figure 13), the lack of Iraqi declaration of such damage, and the absence of any UNSCOM findings of bomb-damaged bulk containers.
- According to Iraqi declarations, corroborated by UNSCOM and intelligence information, Iraq moved its viable filled chemical munitions to storage depots to avoid their destruction and facilitate their use if needed. Other than the defective munitions destroyed in Bunker 2, UNSCOM found no other filled chemical munitions at Al Muthanna damaged by aerial bombing.
- According to UNSCOM, production and filling at Al Muthanna had ceased prior to the air war, although small amounts of residual agent in incompletely cleaned production and filling equipment cannot be ruled out.[43] However, UNSCOM did not detect any contamination at the nerve agent production or filling sites.
- Unlike the mustard production site, sarin and VX were loaded into smaller containers (2 m3) and moved out of the production plants soon after production, minimizing the possibility of nerve agent release from bombing.

There is a high likelihood that small amounts of chemical agents leaked from munitions and containers before, during, and after Desert Storm, but we assess that these releases did not reach US troops hundreds of kilometers away. These small releases include leaking munitions, leaking bulk containers, Iraqi destruction of munitions and agents, and residual agents from the damage to the Bunker 2 and mustard production sites. Some of these are included in table 18, appendix L, on leaking munitions. UNSCOM indicated that its Chemical Destruction Group—who regularly operated at the site from 1992 through 1994—never had a positive agent detection on air samplers outside of areas known to be contaminated, indicating that the rate of leakage and evaporation was insufficient to create a measurable hazard, even within much of the facility.

We strongly disagree with published assessments that the bombing of Al Muthanna resulted in a massive nerve agent release visible in weather satellite imagery of 18 and 19 January 1991. Analysis by weather experts clearly indicates that what some have called a release plume is actually a fog bank. Nerve agent vapor is invisible. The spectral, temporal, and spatial characteristics of the weather satellite data are consistent with a fog bank and inconsistent with a plume originating from Al Muthanna. Furthermore, multiple infrared and visible bandwidths show none of the features associated with a cloud of burning material and are wholly consistent with low-altitude water vapor and fog droplets. The airborne material did not originate from Al Muthanna as a plume but appeared suddenly south of Al Muthanna just as fog banks result from rapid condensation of water vapor over an area under favorable atmospheric conditions. In addition, after appearing, the entire mass moved eastward, instead of toward US troops to the south.

Appendix H

Muhammadiyat Probable Nerve and Mustard Agent Releases

During the Gulf war, Muhammadiyat Ammunition Storage Depot was the primary Iraqi chemical weapons storage site outside of Al Muthanna. The first UN inspectors to visit the site in late October 1991 noted total devastation by allied bombing (see figure 30) and numerous damaged mustard- and sarin-filled bombs. In 1996, CIA modeled a release from the site based on Iraq's declaration that 200 250-gauge mustard-filled bombs and 12 DB-2 sarin-filled bombs were damaged. Even with worst case assumptions—such as 100 percent pure agent, complete release of agent payload by all damaged bombs, and favorable cloud transport conditions, the area of contamination at the general population level dosage did not reach US troops. The analysis is covered in the report *CIA Report on Intelligence Related to Gulf War Illnesses*, August 1996.

CIA and DoD subsequently have performed a comprehensive reassessment of agent releases from Muhammadiyat, reexamining intelligence and information provided by UNSCOM—especially photos and videos of the site. In summary, our analyses indicate a slightly smaller nerve agent release and larger mustard agent release. This analysis was presented in an exhaustive joint CIA/DoD report referenced in DoD's recently released Muhammadiyat case narrative but is summarized here. In addition, the case narrative will include an extensive DoD remodeling that indicates that US troops in Saudi Arabia were not exposed.[44]

We believe that multiple nerve and mustard agent releases occurred at this heavily bombed site; that said, our analysis is complicated by the many site release locations and types of chemical munitions. However, some of these releases involved small quantities of agent—as little as the contents of one bomb—which, because of the great distance of this site from US troops, are essentially insignificant. Therefore, only the largest potential nerve and mustard agent releases are presented here and were considered for modeling.

Nerve Agent Release. We now estimate that the amount of nerve agent released from DB-2 bombs (see figure 31) is at least 34 percent smaller than our assessment in 1996. As seen in table 15, this decrease is a result of more accurate information on the bombs:

- We now assess that only 10 bombs released agent because two of the bombs appeared undamaged.
- On the basis of UNSCOM information indicating the bombs were filled in July 1990 and allowing for six months of degradation at the rate used for the Khamisiyah modeling, we now assess that the purity of the agent during January and February 1991 was about 15 percent. In addition, the agent was a 50/50 mix of sarin and cyclosarin as opposed to the previous assessment that it was entirely sarin.
- Analysis of UNSCOM photography indicates that the bombs were not subjected to a fire as earlier assessed, causing us to increase our estimate of the release percentage from 10 to 50 percent—the new number based on nerve agent evaporative testing.

Iraqi movement of bombs at Muhammadiyat prior to the UNSCOM inspection in October 1991 prevents us from pinpointing where and when the damage occurred. Thus, agent could have been released during one or more bombing attacks on Muhammadiyat from 19 January 1991 to 24 February 1991. 2001 DoD modeling looking at the maximum release on all the bombing dates indicates low-level contamination did not reach US troops. Although the Iraqi placement of bombs prior to the inspection opens the possibility they were actually damaged at another site, UNSCOM information indicates that some nerve-agent filled DB-2 bombs were at the site starting in July 1990.

Mustard Agent Release. We conclude that a large release of mustard occurred at Muhammadiyat, almost certainly resulting from Coalition bombing on 10, 12, or 16 February 1991. Furthermore, we now assess that more mustard agent was released than we had estimated in 1996 (see table 16).

- Extensive analysis of UNSCOM information shows that, contrary to Iraq's 1995 declaration of 200 250-gauge

mustard bombs damaged, only 81 250-gauge mustard bombs released agent. However, 266 500-gauge mustard bombs and 20 155-mm mustard shells that were not originally declared by Iraq also released mustard agent. Iraq's original omission of the 500-gauge bombs (see figure 32) was probably the result of confusion with 438 500-gauge bombs burned during the Iran-Iraq war but still present at an adjacent bunker.

- Finally, mustard from 20 155-mm shells is also included in our release estimate because a 1998 UNSCOM inspection indicates that as many as 20 such shells could have been destroyed there by Coalition bombing.
- UNSCOM information indicates that the purity of the agents is around 80 percent[45] but could be as high as 90 percent—we chose the latter as a worst case.
- A CIA contractor's research refined our estimate of the release from burn-damaged bombs resulting in a slightly lower overall release percentage.

Although it is highly likely that a small number of 250-gauge bombs and some of the 155-mm mustard shells were damaged during a different bombing event, the amount released would be insignificant compared to the release on 10, 12, or 16 February 1991. To be conservative, all the munitions were assumed to have released agent at the same time. The maximum amount of agent released is twice as large as that modeled in 1996, primarily because of the larger amount of agent from the undeclared 500-gauge bombs. 2001 DoD modeling using the latest mustard release amounts indicates US troops were not exposed.

Appendix I

Ukhaydir Depot Mustard Artillery Shells

During Desert Storm, Iraq stored about 6,400 155-mm shells filled with sulfur mustard at multiple locations within the Ukhaydir Ammunition Storage Depot (US name Karbala) in southern Iraq. This facility was bombed several times by Coalition aircraft; on two occasions—20 January and 13/14 February 1991—bombs landed near enough to chemical shells to potentially damage these munitions through fire or blast. Bombing on 20 January ignited a bunker near a stack of munitions while a bomb impacted a roadway near a stack on 13/14 February. Although there was no direct evidence that agent was released, in 1997 the IC modeled worst case release scenarios and found that any potential agent contamination would have fallen well short of US troop locations. These results were published in the report *Update on Potential Mustard Agent Release at Ukhaydir Ammunition Depot*, 4 September 1997.

Subsequent information and analysis, however, lead us to conclude that CW agents were not released at this facility—contrary to our 1997 assessments. We highlighted our revised assessment in a February 1999 memorandum to DoD and updated it in October 1999 (both are available on GulfLINK). Although we find it unlikely that any 155-mm mustard shells at Ukhaydir were damaged by Coalition bombing, we cannot rule out leakage of agent from a few shells.

Additional Background

Iraq first admitted the storage of 155-mm mustard shells at Ukhaydir in its revised 1996 declaration to UNSCOM. Prior to that, Iraqi declarations did not mention Ukhaydir but indicated that 155-mm mustard shells were located at the Fallujah Proving Ground (FPG) and Khamisiyah, where UNSCOM inspectors counted over 6,000 shells each in 1991. Iraq's revised declaration indicated that the 6,380 155-mm mustard shells found at FPG had been moved there from Ukhaydir after the Gulf war, but prior to a September 1991 UNSCOM inspection. In April 1997, UNSCOM inspectors were sent to Ukhaydir to investigate Iraq's revised declaration. The inspectors found three 155-mm shells filled with liquid, presumably chemical agent, next to a road that subsequent research indicated was hit by a bomb on 13/14 February 1991 (see figure 33). These shells had not been noticed on a previous UNSCOM inspection of Ukhaydir in November 1991.[46] Later in 1997, another

inspection team obtained a sample from the shells and located a fourth round. Analysis of the sample indicated mustard with a purity of about 96 percent.

Just before a 1998 UNSCOM inspection of Ukhaydir, the Iraqis excavated the site looking for munitions in order to clear the site of any remaining chemical shells. In the process they dug out the area of the original bomb crater under the roadway. They indicated they found 12 additional shells—five under the roadway and seven near where UNSCOM originally found three intact mustard shells in April 1997. UNSCOM examined the 12 shells and found them to be similar to those previously found. They were painted gray, had no sign of being burned, and had some superficial rust. UNSCOM examined the contents of two of the 12 and found them consistent with a mustard fill. The other shells were examined and all found to contain liquid, which was confirmed in 1998 to be mustard with a purity of 94 to 97 percent. UNSCOM examined the site further with ground penetrating radar but did not uncover any additional weapons. Additional information on Ukhaydir can be found in our 1997 papers as well as a February 1999 CIA memorandum to OSAGWI (see bibliography).

Basis for Revised Assessment of No Release

Iraqi actions along with UNSCOM and intelligence information indicate that mustard was not released:

- Iraq maintains that no chemical shells were destroyed at Ukhaydir, even though it was in their best interests to declare them and they were aware of the bombing of the road. In 1997 and 1998, Iraq was under tremendous pressure to explain 550 missing mustard-filled 155-mm shells—a discrepancy publicly debated that UNSCOM listed as one of a handful of key issues Iraq had not resolved.
- It is unlikely that there was a release because such a release would have left signs—spilled agent or munitions fragments—detectable by UNSCOM inspectors who thoroughly examined the area, including using sophisticated ground penetrating radar. Furthermore, there were none of the characteristic odors of mustard degradation products and no contamination detected by chemical agent monitors. It is unlikely that Iraq thoroughly cleaned or decontaminated the site just after the bombing, since 16 mustard-filled shells were found in the immediate area.
- In addition to the obvious soot trail indicating heat from the 20 January 1991 bunker fire that went away from a stack of 155-mm munitions, intelligence indicates no evidence of burn damage to munitions or to the wooden pallets above and below the munitions (see figure 34). We would expect significant fire damage to the pallets because fire-damaged 155-mm shells observed by UNSCOM elsewhere showed extensive signs of charring and structural damage (see figure 35).
- For the 13/14 February 1991 bomb impact near a stack of 155-mm shells, intelligence indicates that the bomb blew up both next to the stack and under the roadway, greatly reducing the impact of the explosion. An underground explosion is corroborated by both imagery showing lack of scatter around the crater and military reporting of the use of a time-delay fuze on the bomb.[47]

Other Ukhaydir Issues

Our previous assessments included worst case assumptions regarding possible releases from eleven unaccounted chemical shells, burned shells, and empty green shells seen by inspectors at the Fallujah Proving Ground. Our updated assessments are presented below.

Eleven Destroyed Shells. In mid-1997, for modeling purposes we conservatively assumed that eleven shells—corresponding to both the difference between 6,394 shells declared by Iraq and 6,383 shells UNSCOM counted (6,380 at FPG in 1991 plus three in 1997) and to a rough calculation of the number hit by a passing bomb—were directly hit by the 13/14 February bomb before it penetrated and exploded under the road. We now assess that the bomb missed the shells, either landing short of the shells or passing over them at a steep angle. In addition, in 1998 Iraq found an additional 12 155-mm shells, negating the missing shells.

Burned Shells. We now assess that 104 burned 155-mm mustard shells found at the Fallujah Proving Ground were not

damaged at Ukhaydir during the air war because of the arguments mentioned above regarding the bunker fire and Iraq's declaration that no munitions were damaged. We now assess that they were much more likely to have burned before the war at Ukhaydir or another site; they also could have been burned after Desert Storm. A more detailed explanation of our assessment of where they could have been burned is contained in appendix J.

Green Shells. Although 107 empty green 155-mm shells were included with the 6,380 shells counted at Fallujah Proving Ground, these almost certainly did not release agent during Desert Storm. These shells are likely early design 155-mm shells left over from Iran-Iraq war storage at Ukhaydir—by Iraqi admission a CW storage site since the mid-1980s. The shells were not of the same type as the more than 12,500 nearly leak proof gray 155-mm shells Iraq filled with mustard and dispersed for the Gulf war.

Appendix J

Burned Mustard Shells Found at Fallujah Proving Ground

As part of our effort to follow up on all possible releases during the Gulf war, we have tried to discover the release date and location associated with about 100 burned mustard shells originally assumed to have been damaged at Ukhaydir (see appendix I). In September 1991, UNSCOM inspectors viewed 104 burned 155-mm mustard shells—94 of which were empty, signifying a release—at Fallujah Proving Ground (FPG) (see figure 25, appendix I). In response to questioning, Iraq explained that the munitions were burned in a fire that occurred when the Iraqis tried to decontaminate leaking shells with bleach at Al Muthanna. Although combining bleach and mustard can cause an exothermic reaction and subsequent fire, the inspectors were skeptical of this explanation.

We assess that they were most likely destroyed **prior** to Desert Storm at one of multiple possible locations although we are unable to assess exactly where and when this release occurred. We no longer believe that these were damaged as a result of Gulf war Coalition aerial bombing at Ukhaydir as previously assessed. On the basis of our past modeling (see appendix C), it is unlikely US troops were exposed because the likely locations of the fire are too distant for contamination to reach US troops from such a small release. The possible release sites below are ranked based on available information with the most likely first:

- ***Ukhaydir Accident or Intentional Destruction (Pre-Gulf war).*** Iraq indicated that it had used the Ukhaydir facility for chemical agent storage in the mid-1980s. It is possible that Iraq discarded the burned shells after an accident occurred or after the shells were deliberately burned during the Iran-Iraq war.
- ***Fire at the Fallujah Proving Ground (Pre-war).*** Iraq's declaration in April 1990 indicated that only 105 155-mm shells were at this facility, in contrast to the approximately 6,400 shells eventually declared and found there. The declaration of 105 shells corresponds well to the 104 burned shells found there later and may indicate that the burned shells had been at this facility all along as part of earlier CW testing.
- ***Al Muthanna Bleach Fire (December 1990/January 1991).*** In this scenario, as originally claimed by Baghdad, the Iraqis accidentally set leaking mustard shells on fire while trying to decontaminate them with bleach at Al Muthanna. These burned shells were subsequently delivered to FPG. Such an event is possible, but we doubt Iraq's production facility would have delivered damaged munitions to a military storage facility.
- ***Fire In Transit From Al Muthanna to Ukhaydir (Early January 1991).*** UNSCOM indicated that a small percentage of mustard shells contained significant amounts of water that could lead to rupture of the munition, potentially during the stresses of travel vibration. Attempts to decontaminate using bleach could have induced a fire.
- ***Trailer Fire (Mid-March 1991).*** In 1998 Iraq declared that, in March 1991, hijackers of a truck carrying 400 155-mm mustard shells set fire to the trailer and munitions on the west side of the Karbala-Najaf divided highway.

However, Iraq never connected the accident to the burned shells found at Fallujah Proving Ground. After analyzing UNSCOM information, we conclude that it is unlikely there was a release of chemical agent from a trailer.[48]

- ***Ukhaydir Bombing Fire***. As discussed in appendix I, this scenario is very unlikely but cannot completely be ruled out because of incomplete knowledge of activities at Ukhaydir.

Appendix K

Al Walid Airbase Suspected Nerve Agent Release

Information suggests Coalition bombing might have released a small amount of nerve agent from the Al Walid airfield in western Iraq (see figure 36). Extrapolation from previous modeling leads us to assess that, if a release occured, it is unlikely that agent would reach US troops in Saudi Arabia because of the small amount released. This would include troops based at the Ar'ar airfield (31° N 41° E) 245 km away.[49] We estimate that a minimum of 40 kg of agent would have been required to reach these soldiers, but we assess that any release would have involved 15 kg of agent at most.

We first knew of Al Walid's use as a CW-related storage site in 1991, but we originally assessed from UNSCOM information that only relatively harmless alcohol-filled R-400 binary bombs[50] were stored at this site. UNSCOM 20 inspected 336 intact R-400 bombs at Al Walid and two nearby airfields in October 1991.[51] In March 1992, Iraq included 160 additional bombs at Al Walid in its declaration of munitions and CW material that it had destroyed unilaterally.

However, in April 1992, UNSCOM 35 inspectors—sent to confirm Iraq's unilateral CW destruction—were told that the additional 160 R-400 bombs at Al Walid were not destroyed by Iraq but rather were destroyed in a fire caused by Coalition bombing. Inspectors were taken to a hardened aircraft hanger where Iraq indicated R-400s had been destroyed in a fire, and they also visited a burial site for burned bombs (see figure 36, figure 37, and figure 38). Intelligence data supports Iraqi claims that R-400 bombs were damaged prior to the July-October 1991 Iraqi unilateral destruction.

Furthermore, newly uncovered 1992 UNSCOM photos and other information indicate some of the 160 R-400s may have been filled with actual agent.

- UNSCOM photos of the burial area at Al Walid show a few R-400 bombs that appear to have ruptured from internal pressure (for example see figure 38). Bombs filled with nerve agent[52] would have had significantly less air volume available for expansion than the binary bombs in question and, therefore, would have been more likely to rupture during a fire.
- UNSCOM has information indicating that Iraq had 12 R-400 bombs filled with a GB/GF mixture at an unknown deployed site. According to UNSCOM, these bombs—filled prior to deployment with the alcohol portion of the binary mixture—would have been filled with DF in the field, creating nerve agent.

The information supporting a nerve agent release at Al Walid is ambiguous, and there are alternate explanations.

- Some of these Iraqi-made bombs might have burst from a combination of normal pressure buildup from environmental heating of the alcohol—perhaps overfilled into the bomb—and defects resulting from poor Iraqi workmanship. Also, the damage could have been caused when Iraq bulldozed the bombs during burial—suggested by damage to burster tubes and fragile tail sections.
- It is possible that the 12 filled munitions initially were at one of seven other declared deployment locations, where R-400s were undamaged by Coalition action.

Without additional information we are unable to assess whether there was a CW agent release from Al Walid. We also cannot be sure of the actual fill because Iraq also filled R-400 bombs with BW agent, an issue that is handled in our previously published BW paper.

Appendix L

Leaking Iraqi Chemical Munitions and Bulk Containers

UNSCOM inspections revealed that a significant number of Iraqi chemical munitions and storage containers were leaking small quantities of CW agents at locations throughout Iraq (see figure 39). Inspectors found leaking munitions at six different sites (see table 17), including multiple locations around the Al Muthanna facility (see appendix G). The leaks varied from a trace amount (detectable by chemical agent monitor) around the threads of one mustard shell at Khamisiyah to about 20 bombs—containing about 1,500 kg of mustard—damaged when Iraq buried them at Al Tuz Airbase in late January or early February 1991.

On the basis of intelligence and UNSCOM information, we assess the bombs at Al Tuz were damaged by a bulldozer during burial—possibly to avoid a release from future Coalition air attacks. Although the airbase most likely came under air attack prior to the burial, intelligence reporting and information on the condition of the bombs indicate they were not damaged by aerial attack.

After carefully reviewing all cases of CW agent leakage identified by UNSCOM, we assess that contamination from leaks of aging and defective Iraqi chemical munitions/bulk storage containers was unlikely to have exposed US troops. In each case, these leaks were either too slow to cause long downwind contamination or too distant to reach US troops. Although we cannot completely rule out a large chemical agent spill by Iraq prior to UNSCOM inspections, Iraq would almost certainly have declared such an event to more fully account for its CW agent stocks.[53]

Appendix M

Iraqi Unilateral Chemical Munitions Destruction

In February 1992, Iraq declared that it had unilaterally destroyed thousands of chemical munitions, hundreds of tons of precursors, and other prohibited items between June and October 1991. Iraq's latest declarations on unilaterally destroyed chemical munitions are listed in table 18 and their locations are shown in figure 40. Iraq has significantly changed and added to its original unilateral destruction declaration, most notably indicating that some of the destroyed munitions Iraq showed inspectors were actually filled with biological agents[54] instead of chemical agents. Iraq told UNSCOM inspectors that chemical munitions unilaterally destroyed were either empty or—in the case of R-400 bombs and warheads for the Al Husayn—were filled with the nontoxic alcohol component of their binary system. We investigated the possibility that a chemical agent could have been released from Iraq's unilateral destruction activities. UNSCOM information—including its detector readings, sample results, and other information—leads us to conclude that no significant release of chemical agents resulted.

- On the basis of UNSCOM information, we agree that most of the munitions unilaterally destroyed were empty or half-filled with alcohol. Although positive CAM readings for CW agents were obtained on some of the munitions, these were not confirmed by subsequent lab testing of samples.
- UNSCOM believes—based on its sampling data—that at least three Al Husayn warheads were filled with degraded VX agent when unilaterally destroyed by Iraq. Because this VX most likely was completely degraded—a conclusion consistent with UNSCOM's understanding of Iraqi VX—explosive destruction of the warheads would have posed no VX release hazard.

A few R-400s could have been filled with agent when destroyed by Iraq. Of note, UNSCOM information indicates that 12 of the deployed R-400s contained unitary agent. Even if true, Iraq could have decontaminated these agent-filled bombs prior to demolition or destroyed them in such a manner to minimize contamination. Thus, we assess that a release from these sites is probably too small to cause low-level contamination of US troops hundreds of kilometers away.

Appendix N

Coalition Reported Detections of or Exposure to CW Agents

The DoD investigates veteran reporting of potential CW-related events and performs detailed investigations on cases it deems credible; these are documented in case narratives found on the GulfLINK website.[55] The Intelligence Community performs a supportive role on such investigations, coordinates the intelligence contained in the reports, and examines relevant information to ensure our own assessments are comprehensive. DoD is still researching some reported incidents and we are prepared to assist them in the evaluation of any additional potential exposure incidents.[56]

Military and veteran reporting reflects genuine concerns about chemical agents during the Gulf war. Such reporting includes allegations of CW agent detections, discovery of CW munitions or bulk storage tanks, and chemical agent exposure or injuries. While seemingly related, we believe, on the basis of DoD research and intelligence information, that the vast majority—if not all—of military- and veteran-reported CW incidents were unrelated to chemical warfare agents. DoD and other information has shown there are many causes of mistaken CW reporting.

- ***False Alarms***. There were probably hundreds if not thousands of reported CW alarms in the Gulf war from detectors such as the M8A1 and Fox vehicle mounted sensors. On the basis of numerous focused investigations and the low likelihood of chemical agents being present at levels above equipment detection thresholds, we believe the vast majority of reports—if not all—were false alarms. These alarms probably were due to the presence of non-CW chemicals whose detector-specific properties closely matched those of CW agents. Unlike laboratory equipment, most field chemical detectors have design constraints[57] limiting their ability to differentiate between many common chemicals or chemical mixtures and true threats. For example, many wartime false positive detections from Fox vehicle mass spectrometers (MS) occurred because the equipment looked for only part of a chemical agent spectra—a design constraint for MS field use—and was fooled when a mixture of other chemicals was present.
- ***Unfamiliarity With Encountered Chemicals/Munitions***. We conclude that many CW allegations resulted from unfamiliarity with the complex issue of CW agents or Iraqi chemical munitions combined with expectations of encountering CW. Materials mistaken for CW include inhibited red fuming nitric acid (a missile propellant oxidizer) leaking from a chemical tank in Kuwait, which was confused for mustard agent; yellow-tipped anti-armor tank rounds thought to be chemical rounds; 55-gallon barrels and other containers thought to contain chemical agents because they were marked with the "skull and crossbones" symbol for common toxic chemicals; strong chemical odors, such as an ammonia smell, which were thought to be chemical agents; and Iraqi Scud propellant released during reentry, which caused burning sensations on skin thought to be caused by chemical agents.

- ***Confusion About Events***. As evidenced by the many differing accounts of specific events, the "fog of war" and passage of time often lead to inconsistencies and inaccuracies in the recalled details of key incidents. In such cases, documentary or other physical evidence can play an important role in the effort to reconstruct these events. In other cases, information indicating that an event was unrelated to CW was not documented or communicated to troops involved and thus helped perpetuate misconceptions about the event.

Moreover, intelligence information indicates it is very unlikely that Iraqi chemical agents were used against US troops or were deployed to undeclared locations where they would have been encountered by US troops.

Czech Detections[58]

Previous Assessment. Chemical troops of the Czech Republic, employed by Saudi forces to perform detection and decontamination functions during Desert Shield/Desert Storm, reported chemical detections to DoD and the press during Desert Storm. Following US Congressional inquiries, the Czech government hosted a DIA-led delegation in 1993 to discuss reported Czech detections of chemical agents. Czech officials told the group that their troops made only two such detections. The first occurred on 19 January 1991, when two separate Czech units detected low levels of nerve agents at about the same time. The Czechs surmised that the agents they detected were released as a result of aerial bombing to the north two days earlier. They also reported that, on 24 January 1991, Saudi forces directed a Czech chemical unit to a remote "puddle"—covering a few square meters—that tested positive for sulfur mustard. The Czechs provided no contemporaneous records of these detections.

An evaluation of this information resulted in the DoD's 1993 statement—based on assessments within the IC—that these detections were credible, though not confirmed. This assessment was based on official Czech information—which was partially contradicted by subsequent information, as shown below—indicating the following:

- The Czech chemical unit had experienced, well trained personnel that used multiple independent tests that would reliably identify the agents sarin and mustard.
- The quality and specificity of the Czech equipment indicated it would be unlikely to generate a false alarm in the presence of normal battlefield gases or chemicals expected in the area.

Latest Assessment of Events. On the basis of the book Desert Fever, various logs, and other information, we assess that there were four events—as opposed to original Czech reports that there were two—that involved positive tests by Czech equipment for chemical agents. Three of these events were on 19 January 1991 while the fourth was on 23 January.

Czech Detection Events

19 January 1991 (all times local)

Event 1: Airborne "Mustard" Detection at Two Adjacent Locations. *At about 1030 hours (local), a Czech NBC reconnaissance squad stationed 3 km upwind of the KKMC headquarters unit indicated it detected mustard agent (see map figure 1). An alarm was given and other Saudi and Czech units were warned and suited up. Some reporting also indicates positive nerve agent detection. Another unit at the KKMC headquarters 3 km downwind from the reconnaissance unit also reported positive mustard detections on a CHP-71 from about 1100 to 1330. The headquarters unit's CHP-71 tests for nerve agent were negative. The Czechs gave an all-clear signal at 1430.*

Event 2: Contaminated Area Tested Positive for Organophosphorus Compound. *At about 1700 the Czechs received a call*

to investigate contamination in the desert near a French depot 60 km from KKMC. The truck mobile AL-1 sent to investigate detected organophosphates, then returned about 2100. The unit reported no sign of munitions or vehicle tracks. A helicopter base was nearby providing a possible source of the contamination.

***Event 3: Positive Test for Airborne Organophosphorus Compound**. At about 1715 the 2nd Czech Battalion attached to the Saudi 4th Brigade north of Hafir al Batin reported detection of airborne organophosphates. The same unit might have detected organophosphates a second time at 2000.*

23 January 1991

***Event 4: Second Positive Test for Airborne Organophosphorus Compound**. About 2340, following a flash and Scud alerts, the 2nd Czech Battalion attached to the Saudi 4th Brigade (the same unit involved in event 3) north of Hafir al Batin detected organophosphates.[59] The detectors probably included a GSP-11 and two CHP-71s. The Czechs gave an all-clear signal by about 0100 on 24 January.*

New Information Indicates Chemical Agent Unlikely Cause of Czech Detections. On the basis of a reanalysis that includes new documentary information, we now assess it is unlikely that the Czechs detected chemical agents. In particular, there is a low likelihood of a source for any chemical agents, the testing procedures were not as thorough as previously explained, and we have determined that other chemicals or quality problems in the deployed detection equipment are plausible causes of the detections.

Lack of Chemical Agent Sources. It is unlikely that any chemical agents from Iraqi facilities attacked around the time of the detections would have reached the detection locations.

- Our extensive analysis of possible locations of Iraqi CW releases from Coalition attacks—all very distant from the Czech detectors—indicates known nerve agent releases occurred no earlier than 19 January 1991. Given the prevailing wind speed, this would have left insufficient time for agents to reach detection sites by the time of the 19 January alarms.
- As indicated previously (see appendix D), we believe it is very unlikely that there were any additional unknown releases of chemical agent in amounts large enough to reach Saudi Arabia for any of the detections.
- A deliberate Iraqi release is unlikely because there was no reliable evidence of such an attack—including a lack of munitions debris or vehicle tracks in the area of the "puddle." In addition, our extensive analysis of available information on Iraqi chemical weapons use, deployment, and motivations argue against a deliberate Iraqi release.
- Although there has been speculation that a Coalition country deliberately released agent as a test of the Czech equipment, this possibility is unlikely. We have no reliable information that any Coalition forces had chemical agents in theater. Release of agents for testing purposes at that time would have been unwise because it could be, and was, initially taken as an Iraqi attack. Speculation on a Coalition release was fueled by the apparent certainty of the 24 January 1991 detection of an unexplained "puddle" of mustard—an episode that is now assessed to be an ambiguous detection of other chemicals on a different date.

New Information Weakens Previous Account of Detection Methodology. New information from Czech documents—most notably those included in a 1999 Czech language book "Desert Fever" co-authored by the head of the Czech units in the Gulf—contradicts previous Czech military statements.[60] As shown below and in table 20, the new Czech information raises doubts about the information used in the IC's previous assessment—especially the detection circumstances such as weather conditions, agents the Czechs thought had been detected, and type of confirmatory testing performed.

As seen in table 19, the new information on the events lessen the confidence that the detections were caused by agent. The

new information calls into question whether the Czechs performed key confirmation procedures important to our previous assessment of detection credibility and opens the possibility that other chemicals or detector problems could have caused the detections. For example:

- Only one nerve agent detection process now appears to have been used, and it is sensitive to not only nerve agents but also other similar compounds found in organophosphate insecticides.
- The detection methodology and confirmation process for the airborne nerve agent detection on 19 January 1991 is uncertain. It is doubtful that there were two separate near-simultaneous detections on 19 January as previously claimed.
- Regarding the 24 January 1991 "mustard puddle" detection, a Czech document contained in Desert Fever—corroborated by other reporting and Czech MOD statements—indicates the contamination involved chemicals other than mustard and occurred on 19 January. Thus, previous information on confirmatory mustard testing is contradicted.

Weaknesses in Deployed Detectors. Although 1994 US technical analysis of Czech-provided equipment indicated that it was excellent at not alarming to common battlefield interferants, the tests did not check all equipment conditions, chemicals, and environmental factors that would be encountered in the field.[61] In addition, subsequently obtained Czech information such as from the book Desert Fever point out concerns with the quality of equipment sent to the field—including the specific equipment used in these detections:

- Of most concern was the age of enzyme used in the GSP-11.[62] In a recent reply to DoD, the Czechs also indicated the detector's buffer can degrade. Though they claim degraded enzymes and buffers would make the detector more sensitive, such degradation would also make it more likely to trigger false alarms.[63]
- Although US technical analysis of Czech-provided equipment indicated that it was excellent at not alarming to most common battlefield interferants, due to the chemical principles by which the detectors operate some non-agent chemicals can cause positive detections. In addition, Desert Fever and a recent Czech response to DoD queries point to quality problems with some deployed Czech chemical detection equipment that were not fully evaluated in the laboratory.
- It is unlikely that mustard vapor would have been detected on 19 January 1991, because the reported local temperature was low enough that the maximum concentration of mustard vapors would have been only marginally detectable by the Czech detection equipment near the source of a mustard release, let alone at points separated by three kilometers.

Blistered Soldier

Early Assessment

On 2 March 1991, a US soldier developed blisters that military medical personnel—including a doctor experienced in CW casualty management—assessed at the time were consistent with mustard exposure on the basis of several indicators:

- Likelihood of mustard in the area: The exposure occurred in southern Iraq and the doctor had been told or assessed that mustard remaining from the Iran-Iraq war was likely to be in the area. Mustard has been known to retain its potency for decades when buried.
- Appearance of blisters: The blisters were one to two centimeters in diameter and appeared identical to "textbook" mustard blisters.
- Delay in blister formation: The soldier's first blisters formed about eight hours after he completed bunker exploration—consistent with a typical delay in mustard blister formation. Initial mustard agent exposure is usually neither painful nor visible, consistent with the soldier's lack of recollection of the initial contact causing the blisters.
- Fox mustard detections: At multiple times between 2 and 4 March 1991, various reporting indicated that mustard was detected by Fox vehicles either at bunkers in the area or on the soldier's clothing.

New Assessment

Previous DoD and CIA assessments declared the event a probable mustard exposure. After reviewing this case as part of this larger CW study, however, the IC subsequently concluded that mustard exposure was unlikely because medical and Fox detection information is inconclusive and mustard was unlikely to have been at that location. Specific reasons supporting this assessment are discussed below.

Medical evaluation. The key doctor indicated his assessment of mustard exposure was only partly based on the soldier's symptoms—small blisters and a possible time delay—because the connection with mustard based on those symptoms alone is weak. The doctor's assessment also relied on information—Fox detections of mustard and likelihood of mustard in the area—that is shown below to have been in error.[64] It is important to note that the doctor himself has indicated that the appearance of the blisters and the time delay themselves are not conclusive. This is stated in the doctor's testimony to the Presidential Advisory Committee in April 1996.

"Now, without solid chemical evidence to prove that the exposure was in fact related to mustard, the strongest indication I have to support mustard as the cause was the eight-hour delay, that latent period between the exposure and the time of first symptoms. ***An exposure later on that the soldier might not have noticed to one of many other rapidly-corrosive or skin-injury compounds remains as an alternative possibility in the absence of full chemical confirmation." [emphasis added]***

The reason for his reliance on "chemical confirmation" is the difficulty in assessing mustard exposure on the basis of symptoms alone. Currently, even blood tests can be inconclusive in judging mustard exposure.[65] Small mustard blisters appear basically identical to blisters caused by thousands of other chemicals.[66] In addition, as indicated in the key doctor's statement above, the soldier was unaware of when he was exposed, and thus the actual time delay in blister formation is unknown. This means other faster-acting blister-forming chemicals—and there are thousands—could have caused the blisters. Furthermore, many chemicals cause delayed blister formation.[67]

Given the large number of blister causing chemicals the soldier could have been exposed to, it is unlikely the true cause will be found. [68] Possibilities include many skin-irritating petroleum products the soldier could have encountered in his demolition of enemy vehicles that day. Also, he may have been exposed to blister-causing chemicals known to be in conventional munitions.

Fox Detections. The statement below from the key doctor's 5 March 1991 medical assessment of the soldier indicates he believed the Fox results to be strong evidence of mustard.

> "The confirmatory Fox spectra findings are also consistent [with mustard exposure]."

We have comprehensively studied available data from instruments in the Fox vehicles involved in the investigations (see table 20) and determined that they are inconsistent with mustard:

- The video-derived Fox mass spectrum from the soldier's flak jacket is missing key peaks in a mustard spectrum, including a primary peak at 63 m/e (representing a mass-to-charge ratio obtained from a mass spectrometer). If even one primary peak is missing—several were in this case—mustard cannot be present in the sample. Four other primary peaks were consistent with mustard—which drove the identification of mustard and confused the Fox detector—but these are also consistent with various other likely contaminants (nylon, soaps, sweat, oils, et cetera).
- The printouts from Fox testing of the soldier's coveralls and testing of the flak jacket by a different Fox vehicle did not confirm the presence of mustard. The instrument readouts primarily indicated "fats, oils, and wax" (indicative of contaminants) and four chemical agents—thiophosgene, lewisite, HQ-mustard, and phosgene oxime. These CW agents almost certainly were false alarms, since Iraq did not deploy these agents (see appendix A).
- Lab tests on the soldier's clothing performed by Edgewood's Analytical Research Division did not indicate the presence of any chemical agents or their degradation products. These tests were more sensitive than the Fox testing

and included a wider array of instruments and methodologies.

- ***Likelihood of Mustard at Storage Complex***. UNSCOM information—corroborated by intelligence—indicates that Iraq did not store mustard shells[69] at the storage location in question. Iraq claimed "dispersion" in mid-January of about 12,600 shells to An Nasiriyah—later moved near Khamisiyah—and Ukhaydir CW storage sites. UNSCOM indicates it has no good information to contradict Iraqi claims that no chemical munitions were deployed further south than these sites. Further:
- The bunkers visited by the soldier were part of a temporary field storage area near likely battle lines whereas Iraq stored chemical munitions in or near permanent rear depots close to or north of the boundary of the Kuwait Theater of Operations (31 degrees north).
- The bunkers and revetments were constructed after the start of the invasion of Kuwait and thus could not contain mustard spilled during the Iran-Iraq war.

Bibliography of Additional IC Gulf War Illness Papers

Date	Title
1996	
2 August	CIA Report on Intelligence Related to Gulf War Illnesses
1997	
26 February	Statement by Acting Director of Central Intelligence, George Tenet
Undated	Continuing Support for the Gulf War Veterans' Illnesses Research: Request for Veterans' Help A one-page flyer produced in coordination with DoD's Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses and distributed 18 March 1997 at the Presidential Advisory Committee (PAC) meeting in Salt Lake City, Utah, and Washington, DC)

18 March	Statement by Acting Director of Central Intelligence, George Tenet
	Creation of Director of Central Intelligence Persian Gulf War Illnesses Task Force
	(Statement of Robert D Walpole, Special Assistant to the Acting DCI for Persian Gulf War Illnesses Issues, before the Presidential Advisory Committee meeting in Salt Lake City, Utah)
	Status of the Director of Central Intelligence Persian Gulf War Illnesses Task Force Support to Efforts for Modeling the Chemical Release from the Khamisiyah "Pit" Area
	(Statement of Robert D Walpole, Special Assistant to the Acting DCI for Persian Gulf War Illnesses Issues, before the Presidential Advisory Committee meeting in Salt Lake City, Utah)
19 March	Central Intelligence Agency Statement on Khamisiyah
9 April	Khamisiyah: A Historical Perspective on Related Intelligence
16 April	Statement for the Record by Robert D Walpole
	(Special Assistant to the Acting DCI for Persian Gulf War Illnesses Issues, Central Intelligence Agency to the House Committee on Veterans' Affairs, Subcommittee on Health, Subcommittee on Oversight and Investigations)
24 April	Statement for the Record by Robert D Walpole
	(Special Assistant to the Acting DCI for Persian Gulf War Illnesses Issues, Central Intelligence Agency to the House Committee on Government Reform and Oversight, Subcommittee on Human Resources and Inter-governmental Relations)
	CIA Support to the US Military During the Persian Gulf War
17 July	Reducing Uncertainties in Modeling Demolition Activities in the "Pit" at Khamisiyah (Released at Pentagon Press Conference)
21 July	Highlights of Intelligence Warnings About Chemical Weapons at Khamisiyah
24 July	Modeling the Chemical Weapons Agent Release at the Khamisiyah Pit
	(Released at Pentagon Press Conference)

29-30 July	17 Suspect CW/BW Storage Sites Identified in 28 February 1991 CENTCOM Message
	(Statement for the record by Robert D Walpole, Special Assistant to the Director of Central Intelligence for Persian Gulf War Illnesses Issues, CIA, before the Presidential Advisory Committee in Buffalo, New York)
	Probable Release of Mustard Agent from the Ukhaydir Ammunition
	Storage Depot
	(Statement for the record by Robert D Walpole, Special Assistant to the Director of Central Intelligence for Persian Gulf War Illnesses Issues, CIA, before the Presidential Advisory Committee in Buffalo, New York)
4 September	Maymunah Munitions Depot
	(One-page testimony released by Robert D Walpole, Special Assistant to the Director of Central Intelligence for Persian Gulf War Illnesses Issues, CIA, before the Presidential Advisory Committee in Alexandria, Virginia)
	Update on Potential Mustard Agent Release at Ukhaydir Ammunition
	Storage Depot
	(Released as part of briefing by Robert D Walpole, Special Assistant to the Director of Central Intelligence for Persian Gulf War Illnesses Issues, CIA, before the Presidential Advisory Committee in Buffalo, New York)
	Status of the Efforts of the DCI Persian Gulf War Illnesses Task Force.
	(A statement for the record by Robert D Walpole, Special Assistant to the Director of Central Intelligence for Persian Gulf War Illnesses Issues, CIA, before the Presidential Advisory Committee in Alexandria, Virginia)
	16 Suspect CW/BW Storage Sites Identified in 28 February 1991 MARCENT Message
	(A statement for the record by Robert D Walpole, Special Assistant to the Director of Central Intelligence for Persian Gulf War Illnesses Issues, CIA, before the Presidential Advisory Committee in Alexandria, Virginia)
	Modeling the Chemical Warfare Agent Release at the Khamisiyah Pit
	(Produced jointly with the Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses)
December	Lessons Learned: Intelligence Support on Chemical and Biological Warfare
	During the Gulf War and on Veterans' Illnesses Issues

2000

July	Intelligence Related to Possible Sources of Radioactive Contamination During the Persian Gulf War
August	Intelligence Related to Possible Sources of Biological Agent Exposure During the Persian Gulf War

Glossary

ARCENT	Army Central Command
BW	Biological Warfare
CAM	Chemical Agent Monitor
CIA	Central Intelligence Agency
CW	Chemical Warfare
DoD	Department of Defense
DIA	Defense Intelligence Agency
FPG	Fallujah Proving Ground
FTIR	Fourier Transfer Infrared Spectrometer
GPL	General Population Limit (see box)
GWI	Gulf War Illnesses
IC	Intelligence Communitya
IRFNA	Inhibited Red Fuming Nitric Acid
KKMC	King Khalid Military City
KTO	Kuwait Theater of Operations

OSAGWI	Office of the Special Assistant to the Deputy Secretary of Defense for Gulf War Illnesses
UN	United Nations
UNSCOM	United Nations Special Commission on Iraq
WMD	Weapons of Mass Destruction

Footnotes:

1 This study examines potential chemical agent exposure to US troops in allied Persian Gulf countries, southern Iraq, and Kuwait. Potential exposure of special operations forces located elsewhere is handled by DoD.

2 The contamination areas the US Government uses for troop notification of potential exposure and epidemiological studies are not actual contamination areas but are the union of multiple expanded computer model estimates of such areas. A union of multiple expanded areas was used to account for some modeling and troop location uncertainties. We thus note that the number actually exposed is smaller than those notified.

3 Physical properties and effects of acute exposure tend to be well understood. However, medical studies provide little information on the long-term effects of low-level doses of these chemical agents.

4 Additional analysis and UNSCOM inspection information leads us to now assess that no Coalition-bombing-induced release of mustard agent occurred at the Ukhaydir site, which we previously assessed to be a potential fourth major release site. Thus, we assess that bombing of Ukhaydir did not cause the burning of the 104 155-mm shells Iraq displayed to UNSCOM in 1991 as previously assumed.

5 Except where otherwise noted, “mustard” refers to the blister agent sulfur mustard, also designated by the symbol H or HD.

6 In its 2001 report, DoD notes that it is possible that fewer than 70 SOF soldiers may have been exposed to low levels of nerve agent from the Muhammadiyat nerve agent release.

7 Computer modeling of chemical releases involves simulating what happens in the environment when chemical agents are introduced. Many of the physical and chemical processes of a release and its downrange dispersion are complex and have inherent uncertainties. To allow for these uncertainties, reasonable worst case source inputs to models were used on events of highest concern to avoid underestimating potential exposure.

8 DoD reports that 2001 DoD modeling of the Muhammadiyat nerve agent release indicates the possibility of exposure of special operations forces behind enemy lines.

9 The models were expanded to account for uncertainty in local concentration due to random turbulence (meander) in the atmosphere. Models do not account for all the uncertainty in the overall wind direction.

10 DoD indicates that it is possible that special operations forces were exposed from nerve agents released by damage caused by Coalition aerial attacks on the Muhammadiyat depot. Low-level exposure would depend on which attack caused the release, the actual weather conditions, and the exact location of the troops.

11 Photographs show that several bombs were split open—most likely because of internal pressure—indicating that they may have been full and, by implication, contained nerve agent instead of just alcohol (a binary component of the agent). UNSCOM believed that a bomb only partially filled with alcohol would not burst because the additional empty volume would allow for heat expansion. We assess that defects in the welding or other factors could also have caused the rupture.

12 The completeness of Iraq's declaration on filled chemical munitions only slightly lessens our concerns about a current Iraqi CW weapon stockpile. The vast majority of Iraq's unaccounted chemical munitions were empty during the war but can be filled rapidly from hidden or subsequently produced bulk agent if needed. In addition, Iraq has a empty weapons production capability. 550 or more 155-mm mustard shells are still unaccounted. Iraq first declared to UNSCOM that these were damaged by Coalition action at the Muhammadiyat Depot but later said that rebels damaged them after the Gulf war. However, the Iraqis provided no reliable evidence for either contention. We assess these shells probably are hidden by Iraq and would be unlikely to have caused exposure even if damaged by bombing.

13 We assess that it is very unlikely Iraq used the 550 or more mustard shells it was unable to account for. These shells have either been hidden by Iraq or, less likely, destroyed during or after the Gulf war.

14 Wartime documents either copied or quoted in Desert Fever, a 1999 Czech book coauthored by the head of the Czech chemical detachment during Desert Storm, contradict previous official Czech accounts of the number of chemical detections, date and time of detections, confirmatory procedures used, and the type of chemical agents detected.

15 Iranian press reports from November 2000 claim that more than 15,000 victims of Iraqi chemical attacks during the Iran-Iraq war have died since 1988, presumably from the effects of these chemical attacks. Judging by previous claims made by Iran, we believe that these victims suffered from acute exposure to CW agents and exhibited classic symptoms of such exposure, including longer term debilitation as found among chemical victims from World War I.

16 The most common long-term symptoms reported by veterans are fatigue, rashes, headaches, muscle aches, joint pain, abdominal pain, diarrhea, hair loss, memory loss, difficulty sleeping, depression, and concentration problems.

17 Iraq tested or fielded CS-dispersing canisters, grenades, mortars (120-mm and 82-mm), rockert-propelled grenades (RPG-7s), smoke rockets, and smoke generators.

18 This study examines potential chemical agent exposure to US troops in allied Persian Gulf countries, southern Iraq, and Kuwait. Potential exposure of special operation forces (SOF) located elsewhere is handled by DoD. For example, in 2001 DoD indicated that fewer than 70 SOF soldiers may have been exposed to low-levels of nerve agent from the Muhammadiyat release

19 The calculation of amount released can be quite complicated due to uncertainties in whether agent is thrown due to bursting, spilled on wood or soil, retained in the munition, or burned in the fire. Our assessments on release amount err on the side of a larger release and therefore tend to decrease only as we get more information about the release, conduct field tests, or as our source modeling capabilities improve.

20 Table 9 is an update of a table provided in a 14 October 1999 letter to DoD in support of its modeling efforts.

21 As an approximation and holding other variables constant, a doubling of the agent amount only increases the downrange contamination by the square root of two (factor of 1.41). Although the effect of weather conditions can be significant, previous modeling covered most days during Desert Storm and multiple time periods within those days due to long-range contamination.

22 Site used was Rafha, Saudi Arabia. We defer to DoD to account for any special operations forces troops closer to sites. Although some of the releases could have occurred after the start of the ground war, we judge that these closer troops would have still been beyond the range of GPL contamination. Finally, we do not consider the effect of agent on aircraft crews, although efficacy of such exposure is uncertain.

23 The prime example is Iraq's omission for almost a year of hundreds of deployed binary R-400 bombs and tens of binary warheads for the Al Husayn missile. In February 1992, Iraq admitted that these and thousands of empty chemical munitions were unilaterally destroyed in the summer of 1991 (see appendix M) and confused the issue further by including BW munitions in with its CW declaration.

24 For example, under UNSCOM supervision Iraq destroyed more intact mustard bombs than UNSCOM inspectors found at declared sites, suggesting the existence of an undeclared deployment site(s).

25 We still have concerns about undeclared pre-Desert Storm deployment of chemical munitions into the KTO. For example, intelligence acquired on 18 August 1990 indicates there may have been an undeclared chemical weapons transfer under way outside a bunker at Khamisiyah (not Bunker 73). However, we have not found any reliable information of additional chemical munitions in the KTO during Desert Storm when Coalition action could have caused a release.

26 As reflected in Iraq's declaration and expected on the basis of type of use, artillery chemical munitions are those most likely to be deployed near Coalition troops. Forward deployment is required because of the limited range of these weapons and the need to move them to ground units opposing Coalition forces. We believe Iraq would be unlikely to hide chemical munitions destroyed by Coalition ground forces because—as with the chemical munitions destroyed at Khamisiyah—Iraq would assume the Coalition was aware of their identity.

27 Iraqi declarations on the number of shells deployed are corroborated by previous information on military requirements. For example, the 6,300 shells each stored at Ukhaydir and Khamisiyah corresponds to reliable intelligence on a previous deployment at Khamisiyah of 6,293 shells needed for four 15-minute barrages. Similarly, 2,160 122-mm rockets at the same sites corresponds to six battalions of nine multiple rocket launchers each with 40 rockets per launcher.

28 UNSCOM has plausibly suggested these shells may be hidden for use by special Iraqi security forces to protect Saddam Hussein.

29 Raw intelligence and Gulf-war-era Intelligence Community lists of suspected chemical weapons storage sites or facilities can be found on GulfLINK.

30 One such suspect site in the KTO, Ash Shuaybah Ammunition Depot (30 16N 47 41E), was visited by UNSCOM in 1997 and showed signs of significant wartime damage. The Iraqis stated that the site had never been used for chemical weapons storage, and UNSCOM found no evidence of chemical munitions at the site.

31 In this case damaged refers to warhead damage causing agent release. Undoubtedly many of the nerve agent-filled rockets were unusable due to damage to the rocket motor or airframe.

32 Earlier UNSCOM inspections had only accounted for about 38 empty rockets leaving as a mystery the outcome of the additional 460+ rockets. As a worst case we assumed all of these unaccounted rockets released agent.

33 The number of rockets releasing agent in the pit could be even lower. UN inspection photographs and video, photographs by soldiers (see figure 18, figure 19, and figure 20), and UN accounting of empty and filled rockets in the pit all indicate that only about 10 percent of the 1,250 rockets—or 125 rockets—lost their agent. In addition, the total empty rockets reported by UNSCOM is about 138—38 by UNSCOM 29 and 100 "significant pieces" unearthed by the 1998 UNSCOM inspection.

34 Only nerve agent-filled 122-mm rockets were brought back to the Al Muthanna CW destruction facility prior to UNSCOM inspections in the field. Other munitions stayed at their storage sites.

35 Further analysis of US troop photos of an Iraqi site layout model of the bunker area found by US soldiers at Khamisiyah has shown that the actual Iraqi bunker number is 71, not 73. When Iraq identified this to UNSCOM as Bunker "73" they probably had trouble identifying the bunker number because of the extent of the destruction. However, for the sake of consistency with earlier publications—and to minimize potential confusion—this bunker will be referred to as Bunker 73 throughout this paper.

36 In approximately the top 75 percent of the bunker about 70 rockets with possible chemical fills were found, along with a total of 200 pieces of munitions. About 140 filled rockets and more than 200 empty pieces were found in the bottom 25 percent (2 to 3 feet).

37 According to DoD, soldiers used more explosives for the 4 March than the 10 March demolition. There was a shortage of explosives for the second demolition; in fact, between the demolitions, Army Engineers even experimented with ways to collapse bunkers to save explosives.

38 This thermal degradation causes sarin and cyclosarin to break down into other less toxic compounds, which in turn either burn or break down further. The net result is that the nerve agent is thoroughly destroyed at higher temperatures.

39 MSE also included the three Fallujah facilities (US name Habbaniyah) and part of the Muhammadiyat storage depot (US name Qubaysah).

40 UNSCOM information indicates leaking rockets reported in this area were part of the more than 6,000 122-mm nerve-agent rockets retrieved from storage depots after the war.

41 Our previous release assessment was based deliberately on some very exaggerated assumptions, because we wanted to determine if a chemical hazard area from such a distant site could reach US troops in Saudi Arabia even under worst case conditions.

42 Al Muthanna was the focus of the mid-1980s BBC Panorama TV special “Secrets of Samarra.”

43 One of the two sarin production sites and the VX production site were significantly damaged and the other sarin production site was undamaged. Filling facilities were all significantly damaged.

44 DoD also addresses the possible exposure of some small groups of special operations forces troops.

45 Purity of Iraqi mustard contained in bombs is lower than the 96 percent purity of 155-mm mustard shells because of degradation due to inadequate sealing of the bombs and UNSCOM indicates some of the bombs were filled prior to 1990.

46 UNSCOM inspected Ukhaydir as an “undeclared site” in 1991.

47 Although we were previously concerned that the drop into the crater could have damaged 155-mm mustard shells, we now assess it is more likely they slid down the side of the crater.

48 Although collateral information does indeed indicate that a trailer was burned at the location at about the time Iraq declared, the evidence at the site does not support destruction of filled mustard shells there. According to UNSCOM, Iraq has been unable to locate actual 155-mm shells, but only pieces of munitions such as burster tubes and base rings, the condition of which is inconsistent with what would be expected from chemical munitions that burned in a fire.

49 We do not cover special operations forces in Iraq because of lack of information.

50 The bombs are deployed about half filled with a mixture of two alcohols—isopropanol and cyclohexanol. The other binary component, DF, would be loaded into the bomb just prior to use, forming a GB/GF mixture in the munition itself.

51 Al Walid Airbase (US name H3 Airbase) had two satellite airfields—Murasana Airfield and Al Tabaat Airfield (US names H3 NW and H3 SW). At Murasana airfield Iraq had two bombs with BW markings indicating a botulinum toxin fill. See the corresponding IC paper Intelligence Related to Possible Sources of Biological Agent Exposure During the Persian Gulf War. (Note that the BW paper erroneously identifies the BW bomb’s location as Al Tabaat.)

52 As mentioned in the previous footnote, an alternative possibility is the bombs were filled with biological toxins.

53 At one point, Iraq did claim that a shortfall in the declared amount of bulk mustard agent at Al Muthanna was due to complete leakage of a 20-metric-ton container, but it was later determined that Iraq initially made the faulty assumption that all such containers were full.

54 We assess that troops were not exposed to biological agents from the unilateral destruction of Iraq’s biological munitions. For more details, see Intelligence Related to Possible Sources of Biological Agent Exposure During the Persian Gulf War, August 2000.

55 DoD and CIA reports related to this topic can be found at www.gulflink.osd.mil.

56 For example, DoD is currently pursuing multiple accounts of M256 kit detections near Rafha, Saudi Arabia in late January 1991.

57 Field design requirements address detection speed, equipment portability, ease of use, maintenance, cost, and false negative (no alarm) rate in the presence of battlefield interferents. The DoD has indicated that the latter requirement was set low to assure troops were protected when actual agent was present—with the subsequent result of an increased false positive (alarm) rate.

58 The French only recently have stated they had chemical agent alerts on January 19-21. We will evaluate their information when it becomes available.

59 We found no indication of Scud or Patriot launches associated with the Hafir al Batin detections.

60 Although inconsistencies with 1993-94 Czech reporting do not by themselves indicate that the detections were false, they reduce our confidence in the validity of the detections because of our reliance on the Czechs for information on these incidents. The Czechs have yet to do a full investigation of these events.

61 For example, controlled laboratory tests of US detection equipment with inhibited red fuming nitric acid (IRFNA) failed to replicate the field responses US and UK soldiers observed with a tank of what is now known to be IRFNA tested at the Kuwait Girl's School in August 1991.

62 In the book Desert Fever, the Czechs indicated that they had to bury about 260 expired GSP-11 indicator charges out of the 350 sent to the Gulf. Other veterans indicated they did not trust the indicator charges because they had been stored in the heat and there was no way to check their condition.

63 Buffers are added to compensate for acids and bases in the atmosphere that could interfere with the GSP-11 alarm. The GSP-11 and the CHP-71 use the active biochemical enzyme butyrylcholinesterase, which breaks down another chemical into an acid unless inhibited by certain organophosphate chemicals. An acid/base indicator, phenol red, is used to check for organophosphate inhibition (slowing or lack of color change) of the enzyme breakdown.

64 Given the inaccurate inputs the doctor had about positive Fox detections and the likelihood of mustard being in the area it is not surprising the blisters were assessed as being related to mustard.

65 A urine test was negative, although this was expected given the minimal exposure, and no blood tests were performed.

66 In addition, mustard blisters can be similar to blisters from sunburn, allergic reaction to chemicals on skin, radiation burns, etc.

67 For example, phenol—a common solvent for many chemicals, including lubricating oils and disinfectants—may take 24 hours to cause blisters on exposed skin.

68 Further analysis of the laboratory testing of some of the soldier's clothes probably would be inconclusive. Besides indicating that there were no chemical agent-related compounds, a short review of the test results shows several skin-irritating compounds, some possible petroleum-related chemicals, and possible disinfectant-related chemicals most likely introduced during his treatment.

69 Iraqi 155-mm shells are the only known mustard munitions one would expect to find at an Army or Republican Guard field storage area such as this. All other mustard munitions were bombs (see appendix D). Note that mustard shells were not prone to leakage and only one shell out of more than 12,000 found at Khamisiyah and Fallujah Proving Ground had a detectable vapor leak (see appendix L). Due to design requirements of tube artillery, 155-mm mustard shells were also difficult to damage by aerial bombing (see appendix I for an example).

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