

REPORT  
OF THE  
**DEFENSE SCIENCE BOARD**  
TASK FORCE  
ON  
PERSIAN GULF WAR HEALTH EFFECTS

JUNE 1994



Office of the Under Secretary of Defense for Acquisition  
and Technology

Washington, D.C. 20301-3140

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OFFICE OF THE SECRETARY OF DEFENSE  
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE  
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION &  
TECHNOLOGY)

SUBJECT: Report of the Defense Science Board (DSB) Task  
Force on Persian Gulf War Health Effects

I am pleased to forward the final report of the DSB Task Force on Persian Gulf War Health Effects. In the Terms of Reference, Dr. Deutch directed the Task Force to review information regarding the possible exposure of personnel to chemical and biological weapons agents and other hazardous material during the Gulf War and its aftermath. The entire matter of unexplained illnesses reported by some Gulf War participants has become one of intense political and emotional interest, and the work of this Task Force contributes materially to the debate.

In the course of their work, the Task Force heard presentations from a wide range of scientific and medical experts from within and outside of the Department of Defense. The members reached consensus on a number of key points, the most viable one of which they found no evidence that either chemical or biological weapons were used against US service members. The report also concludes that none of the proposed etiologies have caused chronic illness on a significant scale in the absence of acute injury at initial exposure.

Another significant finding was that there is insufficient epidemiological evidence at this time to support the concept of any coherent "syndrome". Because many veterans report symptoms similar to "Chronic Fatigue Syndrome: (CFS); the Task Force feels that it would be advantageous to coordinate further research on veterans' illness in this category with ongoing studies of CFS in the civilian population. While much remains unknown about the organic origin of CFS, severe stress, infection and trauma experienced during Desert Storm may well be precipitating causes. Much further work is needed to verify whether the incidence of symptoms can be associated with any specific aspects of ODS experience, or indeed is provably different among ODS veterans compared to other armed forces or the civilian population.

Despite the intense external interest in the results of the report, the Task Force confined their recommendations to actions within the purview of the Secretary of Defense. Specifically,

the Task Force noted that substantial improvements are needed in pre- and post-deployment medical assessments and data handling. The report advises that while carefully controlled treatment protocols may assist in carving out specific syndromes from the broad range of symptoms noted, treatment would be managed on a case-by-case basis directed at the symptoms presented. Finally, high-tech, low-casualty campaigns in exotic places will probably continue to engender a preoccupation with residual health effects as a fact of life for the foreseeable future.

I would like to echo the Task Force's feeling that the Department must clearly enunciate its commitment to care for those that fight their country's wars. The controversy surrounding this issue will likely continue, but implementation of recommendations in this report should move the medical and scientific communities toward a more complete understanding of the problem of Gulf War veterans who are ill. I endorse the report and recommend that you forward it to the Secretary of Defense.

*Paul G. Kaminski*

Paul G. Kaminski  
Chairman



OFFICE OF THE SECRETARY OF DEFENSE  
WASHINGTON, D.C. 20301-3140

DEFENSE SCIENCE  
BOARD

MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Report of the Defense Science Board (DSB) Task  
Force on Persian Gulf War Health Effects

Attached is the final report of the DSB Task Force on Persian Gulf War Health Effects. The Task Force was established by the Under Secretary of Defense (Acquisition & Technology) to review information regarding the possible exposure of personnel to chemical and biological weapons agents and other hazardous material during the Gulf War and its aftermath. Specifically, the terms of Reference requested that the Task Force review:

- all available intelligence and reports of chemical or biological agent detection or exposure during the Persian Gulf War
- scientific and medical evidence relating to exposure to nerve agents at low levels and possible long term effects
- other potential health consequences resulting from low level chemical exposure, environmental pollutants, Kuwaiti oil fires, endemic biologics or other health hazards attributed to Persian Gulf service

The Task Force heard presentations from a wide range of scientific and medical experts from within and outside the Department of Defense. We also reviewed written information from published and unpublished sources that was pertinent to our terms of reference.

In this report, we confine ourselves to conclusions for which there is substantial supporting evidence. There is a substantial hiatus between the imaginable and the plausible and the proven.

On the order of 1 per thousand or less of the troops deployed in Operation Desert Shield/Storm (ODS) have reported symptoms and complaints for which there is not a conventional medical diagnosis and explanation. Many conjectures could be entertained, and would be hard to prove or disprove, about exposures and consequences at this level of outcome; ODS was not conducted as a controlled clinical experiment for our analytical convenience. It might take many years of further investigation to run every conjecture to ground beyond any remote possibility of doubt. In our proceedings, we relied on the veracity of reports briefed to us by the analysts from the Department of Defense, the intelligence community, and other government agencies. In our view, we had unstinting cooperation from all of these; but beyond our examination for face consistency, and an effort to get corroboration from

primary records, e.g. log books, we had no resources or procedure to challenge that veracity.

Accordingly, our conclusions are as follows:

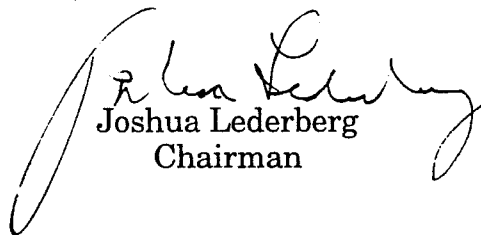
- There is no persuasive evidence that any of the proposed etiologies caused chronic illness on a significant scale in the absence of acute injury at initial exposure. In fact, the overall health experience of US troops in ODS was favorable beyond previous military precedent, with regard to non-combat as well as combat-related disease. This remarkably low background has probably put into relief the residual health problems that have instigated this inquiry.
- The Task Force found no evidence that either chemical or biological warfare was deployed at any level against us, or that there were any exposures of US service members to chemical or biological warfare agents in Kuwait or Saudi Arabia. We are aware of one soldier who was blistered, plausibly from mustard gas, after entering a bunker in Iraq during the post-war period.
- The Task Force felt that there is insufficient epidemiological evidence at this time to support the concept of any coherent "syndrome". We do recognize that veterans numbering in the hundreds have complained of a range of symptoms not yet explained by any clear-cut diagnosis -- a number of cases in many respects resemble the "Chronic Fatigue Syndrome"; it would be advantageous to coordinate further research on veterans' illness in this category with ongoing studies of "CFS" in the civilian population. This is not to deny the possibility of service-connectedness, as severe stress, infection and trauma may well be precipitating causes of "CFS".
- Much further work is needed, even to verify whether the incidence of symptomatic events, beyond the reports of complaints that can be elicited by wide publicity, is associated with any specific aspects of ODS experience, or indeed is provably different among ODS veterans compared to other armed forces or the civilian population. This remark is not to be read as denying service-connectedness, but simply a reflection of the tenuous state of the available epidemiological data in the absence of controlled surveys and studies.

Despite the intense external interest in the results of this report, as our report is to the Secretary of Defense, we confine our recommendations to actions within his purview:

- The Department of Defense needs substantial improvements in pre- and post-deployment medical assessments and data handling. These must obviously be coordinated between DoD and DoVA.

- The appropriate Service medical facilities should ensure that clinical treatment, absent a proven etiology, is managed on a case-by-case basis, directed at the symptoms presented. Carefully controlled treatment protocols might assist in carving out specific syndromes from the broad range of symptoms noted.
- The Task Force advises that high-tech, low-casualty campaigns in exotic places will engender a preoccupation with residual health effects as a fact of life for the foreseeable future. If chemical or biological weapons are ever actually employed, there will be a gross multiplication of those residuals (on top of obvious acute physical and psychological casualties), and further research is needed on long-term consequences of exposure.

In light of the consequences of a perception to the contrary, the Task Force believes that DoD must clearly sustain its historic commitment to providing the highest quality health care to those who serve the nation in their military missions.



Joshua Lederberg  
Chairman

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## **I. OVERVIEW**

The Undersecretary of Defense (Acquisition & Technology) established the Defense Science Board (DSB) Task Force on Persian Gulf War Health Effects to review:

- all available intelligence and reports of chemical or biological agent detection or exposure during the Persian Gulf War
- scientific and medical evidence relating to exposure to nerve agents at low levels and possible long term effects
- other potential health consequences resulting from low level chemical exposure, environmental pollutants, Kuwaiti oil fires, endemic biologics or other health hazards attributed to Persian Gulf service

Members of the Persian Gulf War Health Effects Task Force are:

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Dr. Paul Doty	Professor Emeritus, Harvard University
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Dr. Joseph Bunnett	University of California, Santa Cruz
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Dr. Margaret Hamburg	NYC Commissioner of Public Health
Major General Phil Russell, US Army (retired)	Johns Hopkins University School of Medicine

The following Government and special advisors assisted the Task Force:

### **Government Advisors**

Dr. Ruth Etzel

Dr. Susan Mather

Dr. Ann Norwood

### **Agency**

Centers for Disease Control,  
Department of Health & Human  
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Department of Veterans Affairs  
Uniformed Services University  
of the Health Services,  
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### **Special Advisors**

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United Kingdom

Administrative and research support was provided by Colonel Frank Cox and Major Ben Hagar, Office of the Assistant to the Secretary of Defense (Atomic Energy).

Following a series of fact-finding meetings (Appendix A) the Task Force developed the following principal conclusions and recommendations:

#### A. Conclusions

- There is no persuasive evidence that any of the proposed etiologies caused chronic illness on a significant scale in the absence of acute injury at initial exposure. In fact, the overall health experience of US troops in Operation Desert Storm (ODS) was favorable beyond previous military precedent, with regard to non-combat as well as combat-related disease. This remarkably low background has probably put into relief the residual health problems that have instigated this inquiry.
- There is no scientific or medical evidence that either chemical or biological warfare was deployed at any level against us, nor that there were any exposures of US service members to chemical or biological warfare agents in Kuwait or Saudi Arabia. We are aware of one soldier who was blistered, plausibly from mustard gas, after entering a bunker in Iraq during the post-war period.
- The epidemiological evidence is insufficient at this time to support the concept of any coherent "syndrome." We do recognize that veterans numbering in the hundreds have complained of a range of symptoms not yet explained by any clear-cut diagnosis -- a number of cases in many respects resemble the "Chronic Fatigue Syndrome"; it would be advantageous to coordinate further research on veterans' illness in this category with ongoing studies of "CFS" in the civilian population. This is not to deny the possibility of service-connectedness, as severe stress, infection and trauma may well be precipitating causes of "CFS."
- Much further work is needed, even to verify whether the incidence of symptomatic events, beyond the reports of complaints that can be elicited by

wide publicity, is associated with any specific aspects of ODS experience, or indeed is provably different among ODS veterans compared to other armed forces or the civilian population. This remark is not to be read as denying service-connectedness, but simply a reflection of the tenuous state of the available epidemiological data and the absence of controlled surveys and studies.

## **B. Recommendations**

- The Department of Defense needs substantial improvements in pre- and post-deployment medical assessments and data handling. These must obviously be coordinated with the Department of Veterans Affairs.
- Clinical treatment, absent a proven etiology, must be managed on a case-by-case basis, directed at the symptoms presented. Carefully controlled treatment protocols might assist in carving out specific syndromes from the broad range of symptoms noted.
- We advise that high-tech, low-casualty military campaigns in exotic places will engender a preoccupation with residual health effects as a fact of life for the foreseeable future. If chemical or biological weapons are ever actually employed, there will be a gross multiplication of those residuals (on top of obvious acute physical and psychological casualties), and further research is needed on long-term consequences of exposure. The Department of Defense must plainly sustain its historic commitment to providing the highest quality of health care to those who serve the nation in their military missions.

## **II. TERMS OF REFERENCE**

The full text of the revised Terms of Reference, signed on February 1, 1994, by John Deutch, is as follows:

You are requested to establish a Defense Science Board Task Force regarding the possible exposure of personnel to chemical and biological weapons agents and other hazardous material during the Gulf War and its aftermath. The purpose of this Task Force is to review all available intelligence and reports of detection of the post war period. The Task Force should also review scientific and medical evidence relating to exposure to nerve agents at low levels and long term health effects. A similar review should be conducted for other potential health consequences resulting from low level chemical exposure, environmental pollutants, Kuwait oil fires, endemic biologics or other health hazards. The Task Force may call upon all sources in making its appraisal and should be briefed on background

evidence concerning the possession of CW agents and their use in other settings; however, judgments should be focused on Desert Storm as described above. All DoD-related elements who have technical capabilities that can be brought to bear on this analysis should provide support to this effort. In addition, the Task Force should look at the health-related studies on-going in other governmental agencies.

The Under Secretary of Defense (Acquisition & Technology) will sponsor this Task Force. Dr. Joshua Lederberg will serve as Chairman of the Task Force. Colonel Frank Cox, USA, of the Office of the Assistant to the Secretary of Defense (Atomic Energy) will serve as Executive Secretary. LTC John Dertzbaugh, USA, will be the Defense Science Board Secretariat representative. The Office of the USD(A&T) will provide funding and other support as may be necessary. It is not anticipated that this Task Force will need to go into any "particular matters" within the meaning of Section 208 of Title 18, U.S. Code, nor will it cause any member to be placed in the position of acting as a procurement official. An interim report should be provided by March 31, 1994, and a final report completed by June 15, 1994.

### **III. BACKGROUND**

#### **A. Deployment of troops - Operation Desert Shield**

From August 1990, continuing into 1991, the United States conducted a large-scale military deployment, following the decision to confront Iraq after its invasion of Kuwait. This massive operation involved nearly 700,000 service men and women deployed into the actual theater of operation, with many thousands more assisting the effort from the US and other foreign bases.

As US and other forces began to arrive in the theater of operations, planners were concerned that the large, well-equipped Iraqi Army posed an immediate threat to the coalition force.

Analysts were concerned with the potential for massive combat casualties, predicting as many as 40,000 killed or wounded. There were also early concerns involved with endemic infectious diseases, not unusual for any deployment of US troops to non-developed areas, particularly the array of gastrointestinal pathogens causing vomiting and diarrhea.

#### **B. Stressors of deployment**

The Gulf War brought both old and new threats to American and Coalition forces. There were a number of stressors unique to living in the desert. Familiar and well-publicized threats included venomous snakes and scorpions indigenous to

Southwest Asia. From a medical perspective, however, the largest predictable threat initially was heat injury. Air temperature in the summer can exceed 115 degrees Fahrenheit. Sand receiving full sun is usually 30-45 degrees hotter than the air and can reach temperatures of 150 degrees Fahrenheit. For soldiers wearing chemical protective gear, these temperatures presented a serious risk of overheating and maintaining adequate hydration became a significant challenge.

The desert can also become very cold in the winter with wind-chills at night dropping well below freezing. The sand in the Gulf region was often extremely fine, covering everything with layers of fine dust. After the Iraqis set fire to the oil wells, some troops reported breathing in oily residue and finding a layer of soot coating the environs. Protection of skin and eyes from sand and dust was imperative. The wearing of contact lenses was prohibited except in areas that were air-conditioned and protected from sand. Sunglasses and goggles were distributed for eye protection. Soldiers were also urged to use extra caution in securing tent pegs and other objects that could be turned into missiles by high winds.

Service members in Saudi Arabia had very limited social outlets available to them during infrequent time off. They were culturally isolated, instructed not to fraternize with local people. Also, in accord with the religious dictates of the host country, alcohol was prohibited. Living conditions were harsh: hot showers were an infrequent luxury. Cots were usually lined up side-by-side in buildings, affording virtually no privacy or quiet. The unremitting pace of both the build-up and the war created physically demanding working environments. Support personnel routinely worked 16-18 hour days without respite in order to ensure that logistical goals were met. The use of night vision equipment meant that soldiers could fight effectively around the clock, also contributing to physical strain.

Combat-related stressors included "friendly fire" incidents, tank battles, air-strikes, and other potentially lethal events. The anxiety and apprehension about the use of chemical or biological weapons were omnipresent, with the need for sustained vigilance for incoming conventional or chemical or biological SCUD missiles, and terrorist attacks added to this apprehension. Fears of capture, injury, and death were common concerns of those sent to the combat theater. In the course of the war and its aftermath, many personnel saw the bodies of dead Iraqis and Kuwaitis. The debilitated condition of the Iraqi Enemy Prisoners of War (EPW's) and ethnic minorities such as the Kurds was also distressing to many.

Often, actual combat-related stressors are focused on too narrowly, overlooking the fact that exposures to death, injury and the grotesque are not the only stressors that cause pain and suffering. Other stressors associated with war include the important sequelae of separation from family members and friends. In the case of Reserve and Guard personnel, this also entailed leaving their full-time civilian careers. Many reservists and guardsmen reported feelings of shock and surprise, not anticipating that they would ever have to go to war. Some personnel reported financial problems secondary to deployment. For all service members, normal routines were disrupted and the usual comforts of home became luxuries.



Deployment and reunion also entailed the shifting of normal family roles and their resumption, a challenging process for both service personnel and their families.

### **C. Medical Problems**

Following the triumphant return of the troops from the desert, not unexpectedly, some began to experience health problems. Many of the veterans seen in Veterans Affairs (VA) hospitals following the war were for a normal range of injuries and illnesses, which conformed to established diagnoses.

Initially, only those veterans who could show a service connection for their ailments were able to seek treatment in the VA system. As time went on however, some veterans began to show up at VA centers with unexplained symptoms for which the service-connection could not be determined within established diagnoses and etiologies.

### **D. Registry Efforts**

#### **1. *Characteristics of Deployed Troops***

One of the first efforts undertaken by the Department of Defense (DoD) and VA at the conclusion of the war was to construct a roster of all men and women assigned to military units that served in the Persian Gulf area. Both departments agreed that in order to address anticipated concerns of veterans over exposures to smoke from oil well fires as well as exposures to other environmental hazards, all individuals who served in the area needed to be identified along with appropriate demographic and military information. The Defense Manpower Data Center (DMDC) prepared a computer file of the 696,562 individuals deployed to the Persian Gulf area during the war and provided the file to VA. Table 1 describes the demographic and military characteristics of military personnel deployed to the Persian Gulf area during the Persian Gulf War.

**Table 1**  
**Demographic and Military Characteristics of Participants in**  
**Persian Gulf War**

Characteristics	Active Units (n=580,433) %	Reserve Units (n=72,348) %	National Gd (n=43,781) %	Total (n=696,5 %
<b>Sex</b>				
Male	93.7	84.9	89.1	92.
Female	6.1	14.7	9.6	7.
Unknown	0.2	0.4	1.3	0.
<b>Race</b>				
White	69.6	73.4	77.7	70.
Black	23.3	21.0	18.3	22.
Other	7.0	5.7	3.9	6.
<b>Marital Status</b>				
Single	42.8	49.9	34.7	43.
Married	54.3	44.8	57.8	53.
Formerly Married	2.7	4.9	6.2	3.
Unknown	0.2	0.4	1.4	0.
<b>Rank</b>				
Enlisted	89.3	86.4	90.4	89.
Officer	9.3	12.6	8.5	9.
Warrant	1.4	1.0	1.0	1.
<b>Branch</b>				
Air Force	12.2	7.6	14.7	11.
Army	46.0	64.6	85.3	50.
Marine	15.7	17.8		14.
Navy	26.0	10.0		22.
Coast Guard	0.1			0.
<b>Mean Age (1991)</b>	<b>27.4</b>	<b>30.4</b>	<b>32.6</b>	<b>2</b>

Source: Defense Manpower Data Center

Certain demographic characteristics are substantially different for those who served in active units and those who served in activated reserve or national guard units. Individuals who served in active units were younger (mean age 27.4), and included a relatively smaller proportion of women (6.1%) than those who served in activated reserve or national guard units. Unlike the Vietnam War, a larger portion of deployed troops (17%) originated from activated Reserve and National Guard units.

The majority of troops were deployed in the theater before the air war began on January 16, 1991, and over 50% of the deployed troops were withdrawn from the area by the first week of May 1991. The median length of service in the area was five months. Varying times of entry to and departure from the theater resulted in

some veterans being subject to different natural and man-made environmental exposures. Those who left the theater before the commencement of the air war would not have been exposed to smoke from the oil well fires. Similarly, those who arrived during the period following the conclusion of the ground war would not have been concerned with the threat of biological and chemical warfare, and did not receive prophylactic treatment of pyridostigmine bromide, anthrax vaccine, and botulinum toxoid vaccine. Additionally, the climate and living conditions were substantially different at the beginning of deployment in August 1990 compared to the end of ground war in February 1991.

## **2. *Veterans Affairs***

Public Law 102-585, the "Persian Gulf War Veterans' Health Status Act" of 1992, mandated that the Department of Veterans Affairs (VA) create a registry of the health examinations that may be requested by veterans of the Persian Gulf War. This program allows veterans with health concerns to obtain a comprehensive physical examination with appropriate baseline laboratory tests. Additional diagnostic tests and referrals to specialists are made where indicated. Certain information from these examinations is recorded on a two-page registry code sheet at the local VA hospitals for forwarding to a central location. The code sheet data then is keyed in, and a computerized database is created and updated periodically. VA provides a registry examination to veterans who served on active military duty in Southwest Asia during the Persian Gulf War between August 2, 1990, and the official termination date (which is yet to be established). In addition to providing medical examinations to concerned Persian Gulf War veterans, the registry is being used to assist VA in identifying unusual clusters of illnesses among the veterans and to conduct outreach activities to inform Persian Gulf War veterans of VA programs and policies. As of February 1994, some 16,000 Persian Gulf War veterans have completed the registry examination.<sup>1</sup>

## **3. *Department of Defense***

The DoD Registry program consists of a two year effort to build a computerized system to identify and track the location of veterans, by unit, for each day of the war, to aid in later identification of those units who may have been in close proximity to potential hazards. The program was initiated to identify those units who may have been exposed to the oil fire plumes from burning oil wells in Kuwait during and following the war, but can be adapted to portray other hazards as required. It is expected to be completed by mid-summer 1995.<sup>2</sup>

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<sup>1</sup>Kang, Briefing to DSB Task Force,

<sup>2</sup>US Army and Joint Service Environmental Support Group

## **E. Czech Announcements**

In the summer of 1993, the Czech government officially announced that Czechoslovakian chemical detachments had reported that their detectors for nerve and mustard agents had responded on a few occasions during the war. They stressed that their personnel had suffered no medical effects, and that it was certain that the chemical agent had not been as a result of Iraqi offensive action. A team of DoD analysts traveled to Prague in September 1993, and concluded on the basis of the Czechs' training, equipment and procedures that their account of the detections was credible. There had been no other objective verification of the detections during the war, however, and no samples were taken that could have confirmed the actual presence of chemical agent. At a press conference on November 10, 1993, Secretary Aspin and Under Secretary Deutch discussed the DoD assessment of the Czech detections and the possible medical consequences of those events, had they occurred. It was at this time that the formation of this Defense Science Board Task Force was announced.

## **IV. MEDICAL OBSERVATIONS**

### **A. General**

In previous wars, the expected hazards of war were directly responsible for the overwhelming majority of casualties. The attention of military leaders, their medical forces, and the nation as a whole was focused on the expected and known hazards of war. In WW II, Korea and Vietnam, US forces sustained large numbers of killed, wounded, combat stress casualties and high DNBI (disease/non-battle injuries) rates, especially due to infectious diseases. Post-war military and VA medical care was also focused on veterans who had been victims of the known hazards of war, some of which may have provided convenient explanations for undiagnosable complaints.

The very fact that combat casualties in Desert Shield/Storm period were lower by far than any previous large engagement (See Table 2) has allowed attention to be focused on other aspects of military health.

**Table 2**  
**Historical Casualty Data**

War	Total Deaths #		Admissions per 1,000/day	Admissions per 1,000 per year	Admissions per 1,000/day
	Battle	Other	Wounded (Mideast theater) .40-2.30	Combat Stress	Disease, Non- Battle Injuries (Mideast theater) 1.60-1.96
WW II	292,131	115,185		25.6	
Korea	33,629	20,617	.54-.82	unk	.96-2.14
Vietnam	47,244	10,446	.14-.42	1.6-2.3	.89-.92
Persian Gulf	96	133	354 (total #)	unk	.34-.40

US Army OTSG

## B. Unexplained Medical Complaints in Gulf War Participants

### *What is the Problem*

A certain number of Gulf War participants have come forward with symptomatic complaints, usually of a multi-system nature, and/or non-specific, which they attribute to their experience in the Gulf. Generally, their physical examinations and laboratory results are negative or non-diagnostic. The exact number of such veterans is currently unknown. This group has attracted the attention of the media and some members of Congress.

A variety of studies have attempted to shed light on specific aspects of the problem. These include epidemiological studies by the Army and Navy (123d ARCOM, Seabees), clinical studies (leishmaniasis, depleted uranium), environmental studies (9th ACR) and pathological studies (AFIP). The VA has responded to the diagnostic, clinical and political challenges with a registry of personnel and medical data and tertiary care referral program. Efforts are being made to determine the extent of and consequences of environmental exposure to oil fire products. Lacking however, are a thorough and comprehensive, epidemiologic study and analysis of the entire illness phenomenon.

Although the cases of unexplained medical complaints in Gulf War participants seem to be concentrated in reserve units and seem to affect older individuals, such "risk factors" have not been systematically examined by appropriate epidemiologic methods. The Army and the Navy medical departments have strong preventive medicine assets linked to capable biomedical research organizations. These assets have not been effectively utilized to address the entirety of the problem. Constraints such as the vagueness of the clinical syndrome, lack of a case definition, absence of a biological marker for the disease, and the differences between the medical and patient care systems of the reserves, the VA, and the active forces have been some of the barriers to a comprehensive epidemiological study. These obstacles must be overcome to gain a complete picture of the problem and develop a deeper understanding of the nature of the total health consequences of Persian Gulf War service.

## V. EPIDEMIOLOGICAL CORRELATIONS

### Review of the VA Persian Gulf Registry Data

Of the veterans entered on the VA Persian Gulf Registry, Table 3 describes the distribution of demographic characteristics for 7,427 whose data was available for analysis. Although the number of veterans actually registered continues to increase, the task force was provided data from VA based on analysis of the first 7,247 records to be compiled. Demographic characteristics of those who came to VA for an examination do not appear substantially different from those troops deployed in the Gulf area. However, the military characteristics of the registry participants are significantly different when compared to the characteristics of the entire cohort of deployed troops (Table 4). Even after considering eligibility status for the registry examination, those who served in national guard and reserve units are more likely to have participated in the registry examination than those who served in their counterpart active units. Their rate of registry participation was several-fold greater than their counterparts (see Figure 1, Appendix D). Distribution of time of arrival, departure from and length of stay in the theater for the veterans on the VA registry is not significantly different from those of the overall Persian Gulf War participants (Figures 2-4, Appendix D).

**Table 3**  
**Distribution of Demographic Characteristics of 7,427**  
**Veterans on the Persian Gulf Registry and of 696,562**  
**participants in the Persian Gulf War**

Defense  
Center

Characteristics	PG Registry		Source: Manpower Data
	Number	Percent	
<b>Sex</b>			
Male	6600	88.9	
Female	827	11.1	
Unknown	-	-	
<b>Race</b>			
White	5171	69.6	
Black	1686	22.7	
Other/Unknown	570	7.7	
<b>Marital Status</b>			
Single	2194	29.5	
Married	4062	54.7	
Formerly Married	1171	15.8	
Unknown	-	-	
<b>Age in 1991</b>			
< 24	2245	30.3	
25-29	1441	19.4	
30-34	1097	14.8	
35-39	944	12.7	
40-44	931	12.5	
45+	769	10.4	
<b>Mean Age (1991)</b>		<b>31.6</b>	

**Table 4**  
**Distribution of Military Characteristics of 7,427 Veterans on**  
**the Persian Gulf Registry and of 696,562 participants in the**  
**Persian Gulf War**

Characteristics	PG Registry		Source:
	Number	Percent	
<b>Rank</b>			
Enlisted	6589	87.6	
Officer	391	5.3	
Warrant	97	1.3	
Unknown	430	5.8	
<b>Branch</b>			
Air Force	416	(100)	5.6
Active	187	(45)	
Reserve	79	(19)	
Guard	69	(17)	
Unknown	81	(19)	
<b>Army</b>			
Active	5549	(100)	74.7
Reserve	2095	(38)	
Guard	1398	(25)	
Unknown	1812	(33)	
<b>Marine Corps</b>			
Active	838	(100)	11.3
Reserve	645	(77)	
Unknown	167	(20)	
<b>Navy</b>			
Active	590	(100)	7.9
Reserve	245	(42)	
Unknown	274	(46)	
<b>Coast Guard</b>			
Unknown	71	(12)	
<b>Coast Guard</b>			
Unknown	28	<1	
<b>Unknown</b>			
Unknown	6	<1	

A wide variety of complaints the registry although be entered in computer file centralized Table 5 lists frequent among the veterans. fatigue, joint pain, loss of most mentioned; listed are symptoms the registry and may or been verified by examination.

variety of were made by participants, only 3 could each veteran's for analysis. the ten most complaints 7,427 Skin rash, muscle and headache and memory are frequently complaints subjective reported by participants, may not have objectively physical It is

important to note that information from all veterans on the Persian Gulf Registry has been included. Many of these veterans have received appropriate medical diagnoses for their complaints, so this table does not accurately represent the most frequent complaints for those veterans with unexplained illness. It can also be noted that 1,294 veterans (17.4%) expressed no specific complaints at all.



**Table 5**  
**Ten Most Frequent Complaints Among 7,427 Veterans on the Persian Gulf Registry**

Complaints	Total # of Complaints	Percent of 7,247 veterans with this complaint
Skin Rash	1124	15.1
Fatigue	1044	14.1
Muscle, Joint Pain	981	13.2
Headache	847	11.4
Loss of Memory	823	11.1
Shortness of Breath	521	7.0
Diarrhea	346	4.7
Cough	295	4.0
Choking Sensation, Sneezing, Halitosis, Mouth Breathing	274	3.7
Chest Pain	195	2.6
No complaint	1294	17.4

Table 6 lists the distribution of major categories of diagnosis as reported by VA environmental physicians, by military unit status. There seems to be no significant variation in occurrence of major categories of medical problems, or any specific medical conditions (Table 7) by unit status despite much higher rates of participation and a significantly greater proportion of individuals with complaints among veterans who served in the reserve or guard units. Similarly, distribution of the same categories of medical conditions by branch of service does not vary substantially (Table 8). It was originally assumed that troops who served in one branch of service (e.g., Army) might have different environmental exposures in the Gulf area than troops in another branch of service (e.g., Navy) leading to different patterns of complaints and medical conditions.

**Table 6**  
**Percentage Distribution of Diagnosis for 7,427 Veterans on**  
**the Persian Gulf Registry by Military Unit Status**

<b>Diagnosis (ICD9)</b>	<b>Active (%) (N=3,172)</b>	<b>Reserve (%) (N=1,918)</b>	<b>Guard (%) (N=1,881)</b>
Infectious Diseases (001-139)	233 (7)	136 (7)	117 (6)
Neoplasms (140-239)	46 (1)	28 (1)	26 (1)
Mental Disorders (290-319)	346 (11)	268 (14)	240 (13)
Nervous System (320-389)	225 (7)	141 (7)	148 (8)
Circulatory System (390-459)	177 (6)	135 (7)	130 (7)
Respiratory system (460-519)	506 (16)	288 (15)	318 (17)
Digestive system (520-579)	325 (10)	224 (12)	212 (11)
Genitourinary system (580-629)	90 (3)	63 (3)	63 (3)
Skin & Sub cutaneous tissue (680-709)	393 (12)	249 (13)	248 (13)
Musculoskeletal/connective tissue (710-739)	708 (22)	477 (25)	468 (25)
Injury & Poisoning (800-999)	197 (6)	76 (4)	98 (5)
<b>No medical Diagnosis</b>	<b>760 (24)</b>	<b>399 (21)</b>	<b>487 (26)</b>

**Table 7**  
**Percentage Distribution of Selected Diagnoses for 7,427**  
**Veterans on the Persian Gulf Registry by Military Unit**  
**Status**

Diagnosis (ICD9)	Active (%) (N=3,172)	Reserve (%) (N=1,918)	Guard (%) (N=1,881)
Leishmaniasis (085)	3	4	1
Athlete's foot (110.4)	44 (1.4)	40 (2.1)	24 (1.3)
Anxiety states (300.0)	51 (1.6)	48 (2.5)	30 (1.6)
Neurasthenia (300.5)	138 (4.4)	157 (8.2)	112 (6.0)
Tension headache (307.81)	49 (1.5)	36 (1.9)	35 (1.9)
Chronic PTSD (309.8)	73 (2.3)	51 (2.7)	45 (2.4)
Depressive Disorder (311)	47 (1.5)	39 (2.0)	34 (1.8)
Chronic bronchitis (491)	21 (0.7)	17 (0.9)	20 (1.1)
Asthma, unspecified (493.9)	101 (3.2)	35 (1.8)	41 (2.2)
Chronic airway obstruction (496)	33 (1.1)	30 (1.6)	35 (1.9)
Gingival & periodontal disease (523)	22 (0.7)	16 (0.8)	15 (0.8)
Non-infectious gastroenteritis & colitis (558.9)	110 (3.5)	75 (3.9)	66 (3.5)
Dermatitis, unspecified cause (692.9)	84 (2.6)	65 (3.3)	75 (4.0)
Baldness, alopecia (704.0)	65 (2.0)	33 (1.9)	24 (1.3)
Pain in joint (719.4)	179 (5.6)	134 (7.0)	135 (7.2)
Low back pain (724.2)	105 (3.3)	62 (3.2)	65 (3.5)
<b>Total</b>	<b>3,172 (100)</b>	<b>1,918 (100)</b>	<b>1,881 (100)</b>

**Table 8**  
**Percentage Distribution of Diagnoses for 7,427 Veterans on**  
**the Persian Gulf Registry by Branch**

Diagnosis (ICD9)	Army (N=5549) %	Marine (N=838) %	Navy (N=590) %	Air Force (N=416) %	Total (7427) %
Infectious Diseases (001-139)	7	8	7	6	7
Neoplasms (140-239)	1	1	2	2	1
Mental Disorders (290-319)	13	12	13	11	13
Nervous System (320-389)	8	6	8	7	8
Circulatory System (390-459)	7	3	6	6	6
Respiratory system (460-519)	16	17	14	16	16
Digestive system (520-579)	11	8	10	11	11
Genitourinary system (580-629)	3	3	3	2	3
Skin & Sub cutaneous tissue (680-709)	13	13	11	13	13
Musculoskeletal/connective tissue (710-739)	25	20	23	20	24
Injury & Poisoning (800-999)	6	5	5	14	5
No medical Diagnosis	23	26	23	24	24

Table 9 describes 19 cases of cancer reported in the registry (18 males and 1 female). There is no discernible demographic, military or pathological pattern to the distribution of cancer cases. Because it is a self-selected group of individuals, it would be difficult to make a meaningful comparison with a general population. Whether the observation of 19 cancer cases out of 7,427 examinations reflects an abnormal rate of occurrence is unknown. Furthermore, because of the long latency period associated with cancer originating from environmental exposures, it is too early to evaluate the cancer risk related to Persian Gulf service. Likewise, it is unknown whether some or all of the cancers were present prior to Persian Gulf deployment.

**Table 9**  
**Distribution of Cancer Cases by Site Among 7,427 Veterans**  
**on the Persian Gulf Registry**

Type	<u>Male</u> No.	<u>Female</u> No.
Tongue	1	
Lung	2	
Pleura	1	
Soft Tissue	2	
Melanoma	1	
Other Skin	3	
Prostrate	1	
Testis	2	
Adrenal Gland	1	
Hodgkin's Disease	1	1
Other Lymphoma	1	
Others	2	
<b>Total</b>	<b>18</b>	<b>1</b>

Table 10 summarizes veterans' responses to a question about birth defects in children conceived before service in the Persian Gulf War and in children conceived after veterans returned from the war. According to the registry of 7,427 veterans, 209 veterans reported having children with birth defects: 115 as having been conceived before Persian Gulf war service and 94 after the war. The nature of the birth defects, however, is not defined or verified and the occurrences of birth outcomes are based on self-reports.

record is prepared for each discharged VA inpatient by the discharging station. Over one million veterans are treated as inpatients in VA hospitals each year. The PTF record contains information on such variables as name, Social Security number, date of birth, sex, marital status, period of military service and discharge diagnosis. Military service during the Persian Gulf era is noted on the record but actual service in the Persian Gulf area is not documented. The PTF was matched with the Persian Gulf War roster of veterans prepared by the DMDC, and VA inpatients who served in the Persian Gulf area were identified. The Task Force was presented data, as of September 30, 1993, that compared the data from 6092 *Persian Gulf veterans* and 6265 *era veterans* (those in service during the same period but not actually deployed to the Gulf) treated in VA hospitals on an inpatient basis.

Table 11 describes the demographic characteristics of 6092 Persian Gulf veterans and 6265 era veterans who were treated in VA hospitals. Women veterans constituted 7.6% of the Persian Gulf veteran patients, whereas 14% of era veteran patients were women. The 7.6% figure may be a simple reflection of the gender distribution of the troops deployed in the Persian Gulf area: 7.2% of the deployed troops were women and 8.8% of the troops excluding those who were still on active duty as of September 30, 1993, were women. Otherwise, the racial distribution, marital status and age distribution of the two groups were similar.

**Table 11**  
**Demographic Characteristics of 6,092 Persian Gulf Veterans**  
**and 6,265 Era Veterans Treated in VA Hospitals on an**  
**Inpatient Basis**

Characteristics	Persian Gulf Vets		Era Vets	
	Number	Percent	Number	Percent
<b>Sex</b>				
Male	5629	92.4	5363	85.6
Female	463	7.6	902	14.4
<b>Race</b>				
White	3863	64.4	4168	66.5
Black	1520	24.9	1442	23.0
Other	709	11.7	655	10.5
<b>Marital Status</b>				
Never Married	2230	36.6	2010	32.1
Married	2400	39.4	2528	40.4
Divorced/Separated	1405	23.1	1633	26.1
Other	57	0.9	94	1.5
<b>Mean Age (years)</b>	29 years		31 years	

**Table 10**  
**Self-Reported Incidence of Birth Defects Among Veteran's Children**

Events	Number	Percent
No children born	1565	21.1
No birth defects	5653	76.1
Yes birth defects	209	2.8
Conceived before Persian Gulf Service	115	1.5
Conceived after Persian Gulf Service	94	1.3
<b>Total</b>	<b>7427</b>	<b>100</b>

In analyzing and describing the registry data, it is necessary to recognize many limitations related to the source of the data and therefore to exercise great caution in its use. The veterans in the registry are a self-selected group of veterans who are concerned about the possible adverse health effects of service in the Gulf area and who were willing to come to VA hospitals for physical examinations. Many veterans who are covered by civilian health insurance may be seeking their health care through a civilian health care provider. In addition, a majority of troops who served in the war are still in service with active units, and they would not yet seek medical care from a VA hospital. Therefore, the registry participants may not be representative of either the troops deployed in the Gulf area overall or of those who are eligible for medical care from VA. One cannot be sure whether certain symptoms and diseases in the registry participant population are under-represented or over-represented. A valid external comparison of health outcomes from this group to another population is difficult to make for this reason.

In spite of the several limitations to the VA registry, it serves as a useful tool in suggesting areas for further in-depth reviews and study. The registry can provide an opportunity to identify possible adverse health trends on which to base the design and conduct of appropriate epidemiologic studies.

**1. VA Hospital Discharge Data for Persian Gulf War Veterans**

The Patient Treatment File (PTF) is a computerized hospital discharge abstract system of inpatient records, including patients' demographic data, surgical and procedural transactions, and patient movement and diagnosis. One PTF

Table 12 describes the distribution of military characteristics of these patients. This distribution is also a reflection of the characteristics of the troops deployed in the Persian Gulf area. For example, the distribution of Army troops deployed in the area by unit status is 76% in active units, 13% in reserve units and 11% in national guard units. Excluding those who were still on active duty, the distribution is 60% in active units, 22% in reserve units and 18% in national guard units. In the PTF, the distribution of Army Persian Gulf veteran patients by unit status is 58% in active units, 23% in reserve units and 19% in national guard units. Unlike the Persian Gulf Registry, veterans who served in the reserve or guard units are not over-represented in the VA inpatient population. It could not be determined whether Persian Gulf War veterans were over-represented in the VA inpatient population because different eligibility rules covered hospital admission for different service era veterans.



**Table 12**  
**Distribution of Military Characteristics of 6,092 Persian Gulf**  
**Veterans Treated in VA Hospitals on an Inpatient Basis,**  
**696,562 Participants in the Persian Gulf War, and 371,197**  
**Potentially Eligible for VA Medical Care**

September 30,	Characteristics	VA Inpatients Percent	Gulf War Participants (Percent)	*As of 1993
<p>Table distribution categories of diagnosis. appears to be variation type of conditions for groups of treated. One exception is more Persian were treated adjustment including the era patients. A review of the diagnoses for veteran showed results</p>	<b>Rank</b>			
	Enlisted	96.8	89.1	13 lists the
	Officer	2.7	9.6	of major
	Warrant	0.5	1.3	discharge
	Unknown	1.7	-	There
	<b>Branch</b>			no significant
	<b>Air Force</b>	(100) 5.5	(100) 11.9	between the
	Active	(80)	(85)	medical
	Reserve	(8)	(7)	which the two
	Guard	(12)	(8)	patients were
	<b>Army</b>	(100) 59.6	(100) 50.4	possible
	Active	(58)	(76)	that relatively
	Reserve	(23)	(13)	Gulf veterans
	Guard	(19)	(11)	for
	<b>Marine Corps</b>	(100) 15.3	(100) 14.9	disorders
	Active	(88)	(88)	PTSD than
	Reserve	(12)	(12)	veteran
	<b>Navy</b>	(100) 19.7	(100) 22.7	separate
	Active	(88)	(95)	discharge
	Reserve	(11)	(5)	women
	<b>Coast Guard</b>	6	<0.1	patients also
				similar
				(Table 14).

**Table 13**  
**Distribution of 6,092 Persian Gulf Veterans and 6,265 Era**  
**Veterans Treated on an Inpatient Basis By Selected**  
**Diagnostic Group**

Discharge Diagnoses (ICD 9)	Persian Gulf Veterans		Era Veterans	
	Number	Percent	Number	Percent
Infectious and parasitic diseases (001-139)	183	2.5	222	2.9
Malignant Neoplasms (140-208)	127	1.7	187	2.4
Other Tumors (210-239)	74	1.0	104	1.4
Mental Disorders (290-319)	2556	34.7	2356	30.6
Alcohol dependence (303)	856	11.6	759	9.9
Drug dependence (304)	373	5.1	316	4.1
Adjustment disorders including PTSD (309)	446	6.1	268	3.5
Diseases of nervous system and sense organs (320-289)	259	3.5	368	4.8
Diseases of circulatory system (390-459)	258	3.5	375	4.9
Diseases of respiratory system (460-519)	389	5.3	375	4.9
Diseases of the digestive system (520-579)	812	11.0	767	10.0
Diseases of the genitourinary system (580-679)	292	4.0	360	4.7
Skin and subcutaneous tissue (680-709)	172	2.3	147	1.9
Diseases of the Musculoskeletal and connective tissue (710-739)	669	9.1	828	10.8
Injury and poisoning (800-999)	671	9.1	625	8.1
Others	903	12.3	974	12.7

Note: These tabulations represent primary diagnosis from all inpatient visits, with some veterans having more than one inpatient stay. Percentages are of either the total number of diagnoses for Persian Gulf Veterans (7365) or the total number of diagnoses for the Era Veterans (7688).

**Table 14**  
**Distribution of 463 Women Persian Gulf Veterans and 902**  
**Women Era Veterans Treated on an Inpatient Basis By**  
**Selected Diagnostic Group**

Discharge Diagnoses (ICD 9)	Persian Gulf Veterans		Era Veterans	
	Number	Percent	Number	Percent
Infectious and parasitic diseases (001-139)	12	2.1	26	2.3
Neoplasms (140-239)	18	3.1	75	6.6
Mental Disorders (290-319)	188	32.1	282	24.9
Alcohol dependence (303)	18	3.1	45	4.0
Drug dependence (304)	21	3.6	22	1.9
Adjustment disorders including PTSD (309)	38	6.5	47	4.1
Diseases of nervous system and sense organs (320-289)	27	4.6	77	6.8
Diseases of circulatory system (390-459)	12	2.1	36	3.2
Diseases of respiratory system (460-519)	28	4.8	53	4.7
Diseases of the digestive system (520-579)	50	8.6	89	7.9
Diseases of the genitourinary system (580-679)	78	13.3	150	13.2
Skin and subcutaneous tissue (680-709)	10	1.7	14	1.2
Diseases of the Musculoskeletal and connective tissue (710-739)	60	10.3	117	10.3
Injury and poisoning (800-999)	24	4.1	69	6.1
Others	78	13.3	146	12.9

Note: These tabulations represent primary diagnosis from all inpatient visits, with some veterans having more than one inpatient stay. Percentages are of either the total number of diagnoses for Persian Gulf Veterans (585) or the total number of diagnoses for the Era Veterans (1134).

Persian Gulf veterans who received inpatient medical care at VA hospitals are similar to overall troops deployed in the Persian Gulf area with respect to their demographic and military characteristics. The types of medical conditions for which they were treated were also similar to other veteran patients who were in the military during the same period. No one category of medical condition is either over-represented or under-represented among the Persian Gulf veteran patients in comparison to the era veterans, with the possible exception of mental disorders. The reason for the apparent variation needs to be evaluated further.

Because the rules and regulations governing the eligibility of VA hospital admission may affect the Persian Gulf veterans and the era veterans differently, one needs to be cautious of a simple comparison of these two groups of veterans. On December 20, 1993, legislation was enacted into law which authorized priority health care for Persian Gulf veterans for both outpatient and inpatient treatment (Public Law 103-210). The same priority consideration is not authorized for the era veterans.

## 2. *VA Referral Centers*

In August 1992, the Department of Veterans Affairs established three referral centers at its medical centers in Houston, Texas, West Los Angeles, California and Washington, DC to evaluate cases of undiagnosed illnesses being reported by veterans of the Persian Gulf conflict. These centers were selected for three major reasons: because of their geographic location (East Coast, Middle U.S., and West Coast), because of their own special clinical expertise, and finally because of their geographic proximity to other centers for military medicine, occupational health and toxicology.

A Persian Gulf veteran, whose condition has evaded diagnosis at the local VA facility, can be transferred to one of the designated centers for tertiary consultation, diagnosis, and management. The transfer of a Gulf War veteran is a mutual decision made by the physicians at the originating medical center and the referral center of jurisdiction. Because of the multisystem nature of many of the veterans health complaints, these evaluations are often quite extensive, involving consultations by multiple subspecialty services and entire array of diagnostic tests.

As of February 1994, the Centers have admitted 84 Persian Gulf veterans under the Referral Center Program. The predominant complaints include skin rash, chronic fatigue, muscle aches and spasms, joint pain, diarrhea, abdominal pain, shortness of breath, chronic cough, weakness, dizziness, headache, and memory loss. These symptoms occur singly or, more often, in combination. VA investigations of the health problems of these individuals have resulted in the diagnosis of a diverse group of disease entities including: asthma, inflammatory bowel diseases, irritable bowel syndrome, gastrointestinal parasitic infection with giardia, gastritis, abnormal liver function tests, rheumatologic conditions including Reiter's Syndrome, Sjogren's syndrome and fibromyalgia, idiopathic thrombocytopenic purpura (ITP), a pituitary tumor with neuroendocrine dysfunction, cases of dizziness due to vestibulitis or vestibular dysfunction, CNS vasculitis, sleep disorders, compression neuropathies and various common skin conditions including nevi, warts and fungal infections. Psychiatric diagnoses included major depression, post-traumatic stress disorder (PTSD), somatization disorder and panic disorder. Psychiatric conditions were listed as one of the discharge diagnoses in 20 of the 84 patients admitted to the referral center programs. It is the VA's best medical judgment that these diagnoses do not point to a single inciting cause or agent. Some of these cases still remain undiagnosed at present.

## 3. *Depleted Uranium (DU) Surveillance Program*

During the Persian Gulf War, 15 Bradley Fighting Vehicles and 9 Abrams tanks were mistakenly attacked and struck by DU munitions. Some crew members who survived sustained wounds and have retained fragments of presumed DU shrapnel. An initial check by the Army Office of The Surgeon General has revealed that there were 22 soldiers clearly identified whose records indicate that they have

imbedded fragments that might contain DU. There are additionally 13 soldiers who were wounded and hospitalized but were not specifically identified as having shrapnel. Other crew members (in addition to the 35 already discussed) were either not wounded during the incident or received first aid for minor wounds in the battlefield. The latter two groups of soldiers might have inhaled DU or experienced DU contamination of wounds.

The concern for these soldiers centers principally on the possibility that fragments could serve as a reservoir for absorbable uranium. Animal and human studies have shown uranium to be nephrotoxic.

The Department of Veterans Affairs has recently established a clinical surveillance program at the Baltimore VAMC (Veterans Affairs Medical Center) to identify individuals with retained depleted uranium (DU) fragments, DU contaminated wounds or significant amounts of inhaled DU. This clinical surveillance will provide early detection of untoward health effects related to the presence of DU, an epidemiologic follow-up program and provide recommendations for treatment to participating veterans and the physicians caring for them.

Patients will undergo a thorough clinical evaluation including exposure history and review of systems, administration of health status questionnaire, neuropsychiatric test battery and laboratory testing. Lab tests obtained will include CBC, platelet count, free erythrocyte protoporphyrin to assess bone marrow effects. Bilirubin, transaminases and alkaline phosphatase will assess liver injury. CPK and aldolase will be measured to assess muscle injury. Particular focus will be placed on measures of renal injury. Serum will be analyzed for creatinine, BUN, electrolytes, glucose, calcium and phosphorus. A 24-hour urine will be collected for measurements of creatinine, glucose, beta-2-microglobulinuria, and urine protein. Fragment size will be estimated using plain x-rays and MRI. Blood and urine uranium levels will also be measured. Finally, individuals will undergo whole body counting at the Environmental Protection Agency (EPA) laboratory at Las Vegas, Nevada.

In addition, 27 other veterans from the 144th Supply and Service Company (Army National Guard) performed clean-up of contaminated vehicles. As they entered and re-entered vehicles over a three-week period, it is believed that they had the potential to inhale or ingest depleted uranium residues. Because of this potential risk, a screening program was instituted for this Company. Twelve of the twenty-seven individuals have undergone whole-body counting at the Boston VA Medical Center, all with negative results. Urine samples were also analyzed for depleted uranium; all had negative results. The remaining fifteen individuals have been contacted and have chosen not to be tested.

#### **4. *Birmingham Pilot Program***

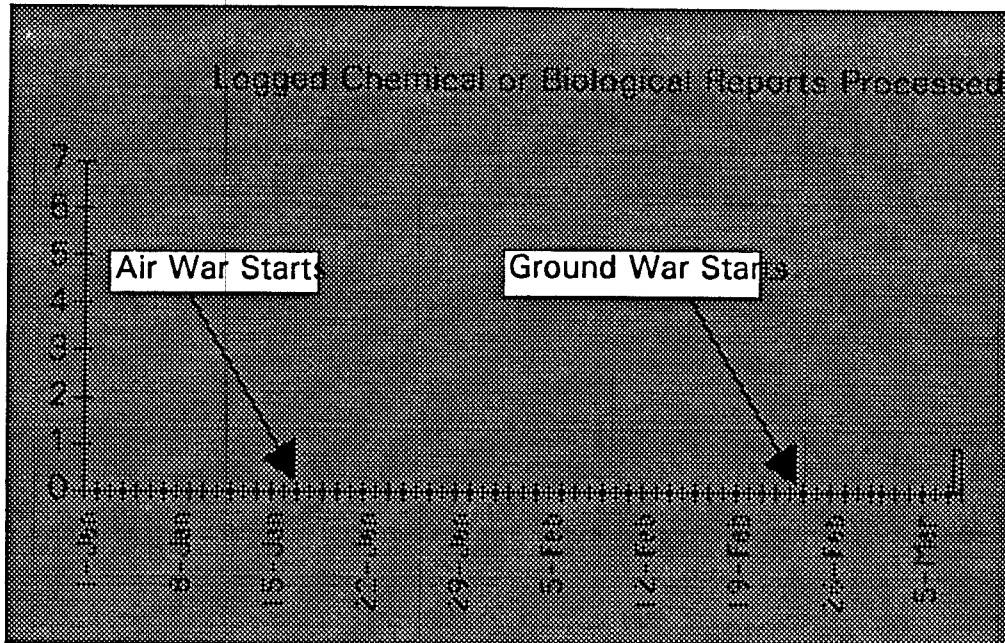
The Birmingham VA Medical Center has been designated by the Secretary of the Department of Veterans Affairs as a Center for Persian Gulf Veterans Chemical Agent Pilot Site. The Birmingham VAMC will begin testing Persian Gulf veterans

from Alabama and Georgia who believe that they may have been exposed to chemical-biological warfare agents. The Birmingham VAMC program will administer a clinical symptom screening survey, perform detailed occupational health exams for veterans with positive symptom survey and administer a neuropsychological testing battery in order to assess potential health effects of CBW exposure.

## VI. CHEMICAL/BIOLOGICAL WARFARE

### Overview

One focus of concern about the exposures that might have led to adverse health effects has been the possibility of their exposure to chemical and/or biological weapons. Saudi Arabia during both Desert Shield and Desert Storm was an environment in which there was a significant threat that this unfamiliar class of weapons might be used. The troops were very aware of the chemical and biological threat, and were nervous about it. Iraq had developed several types of chemical weapons, and had previously used sulfur mustard (HD, a blister agent) and nerve agent in the war with Iran. It had publicly threatened the use of chemical weapons in the Gulf War. It was also believed to have an active program developing biological weapons (in particular, anthrax and botulinum toxin). Many of the coalition forces *expected* to encounter chemical and/or biological weapons, and had trained extensively for this encounter. This tension and anticipation resulted in clusters of alarms and warnings, anecdotal stories and rumors concentrated in the periods in which the tempo of the war increased (the start of the air war, and again starting just before the ground war.) The figure below illustrates the increase in the number of reports logged within the NBC (Nuclear, Biological and Chemical) cells of the Central Command, Army Central Command and VII Army Corps.



Careful analysis by the Coalition forces following Desert Storm led to the conclusion that there was no intentional, tactical use of either biological or chemical weapons by Iraq during the war. More recently, however, the possibility has been recognized that there might have been other types of releases of chemical or biological agents, most plausibly during bombing of Iraqi munitions bunkers or production facilities. This section summarizes an analysis, drawn from information collected predominantly from U.S. sources, but with corroboration from British sources, of evidence relevant to possible exposures of U.S. forces to biological and chemical agents.

#### *1. Biological Agents.*

Biological agents are easily recognized through their effects on a target population. The effects of the two most likely Iraqi agents--botulinum toxin and anthrax--are very well understood and easily recognized.

Table 15  
Biological Agent Symptoms/Effects

BW Agent	Likely Dissemination	Symptoms/Effects	On-Set
Anthrax	1. Aerosol	Initial symptoms mild and non-specific. Followed by abrupt onset of difficult or labored breathing, fast or irregular heartbeat, with rapid progression to blueness of skin, shock and death.	1-6 Days
Botulinum Toxin	1. Food & Water Supply 2. Aerosol	Flaccid paralysis of arms and legs, difficulty swallowing, double vision, paralysis and drooping of the eyelid, generalized slight or incomplete paralysis, respiratory arrest, death.	Hours-days

Anthrax, in particular, can be immediately identified in an afflicted individual, both by symptoms and by direct detection of the organism. There were no reported cases of botulinum toxicity or of infection by anthrax (although anthrax is enzootic in that region of the Gulf, and is the occasional cause of death in animals). Examination of bunkers in the southern and eastern parts of Iraq (that is, the part closest to the U.S. forces) after the war revealed no biological weapons, and no evidence that they had been deployed and then retrograded. Inspections in the post-war period by UN biological weapons teams found no weaponized stores of toxins, spores or organisms (although this finding does not answer the question of the size and scope of the Iraqi program in biological weapons, since the evidence has almost certainly been hidden or may have been destroyed in the period immediately after the ground war). Interviews with senior Iraqi officers after the war confirmed that neither chemical nor biological weapons were used, or deployed in anticipation of use. It thus appears that Iraqi forces made the strategic decision not to deploy or use biological weapons in the Gulf war.

## 2. *Chemical Agents.*

Attention has also focused on chemical weapons, and the possibility that troops were targeted by these weapons, or were exposed to low levels of chemical warfare agents. It is important to recognize that the nature of an attack with chemical weapons is to produce a localized concentration of chemical warfare agent that is sufficient to kill or incapacitate unprotected personnel in the immediate area of attack. The cloud of chemical warfare agent vapor resulting from an attack is dispersed through diffusion into the atmosphere both horizontally and vertically. The rate of this process of dispersion is determined by the nature of the local meteorological conditions. During conditions of atmospheric stability, the cloud can present a hazard for a kilometer or so downwind of the point of attack but this distance is significantly reduced under unstable atmospheric conditions that prevail for most daytime hours in the Gulf. As a result, the concentration of chemical warfare agents in the air is reduced to an insignificant level very rapidly as a



function of distance and time. So far as has been currently determined, there was no use of chemical weapons during the war. Any exposure would have had to resulted from accidental release following bombing of storage bunkers or deployment sites.

Table 16  
Chemical Agent Effects

<u>Agents</u>	<u>Toxicity</u>	<u>Signs and Symptoms</u>	<u>Antidotes</u>	<u>Care</u>
<u>Nerve Agents</u> GA (Tabun) GB (Sarin) GD (Soman) GF VX	-Immediately life-threatening -Causes paralysis by interfering with transmission of nerve impulses	Eye, nose, lung, and gastro-intestinal effects. Large dose: almost immediate loss of consciousness, convulsions, cessation of respiration, flaccid paralysis, copious nasal and oral secretions, intense bronchoconstriction.	-Pyridostigmine bromide pre-treatment -Atropine sulfate, pralidoxime chloride after exposure	Administration of antidotes, ventilation, administration of diazepam (Valium)
<u>Blister Agents</u> Sulfur mustard Lewisite	-Delayed effects; large dose life-threatening if untreated -Injures eyes and lungs and burns/blisters the skin -Lewisite causes immediate pain	Erythema; vesication; burns; eye, lung, and skin damage; respiratory effects; leukopenia; thrombocytopenia; decrease in red blood cells; sepsis	None; decontamination within 2 minutes to prevent tissue damage	Burn care, eye therapy, pulmonary support

### 3. *Evidence for the Presence of Chemical Agents in the Gulf Theater.*

Iraq possessed large stores of chemical weapons, and deployed them to rear storage areas, with the closest of those to U.S. forces located northeast of Kuwait, about 150 km from the Saudi border. Information on the location and conformation of these storage areas was derived from analysis of intelligence information before and during the war, and from on-site examination of them after the war. Iraq is believed to be the only nation that had chemical weapons in the Gulf theater.

During and immediately after cessation of the active campaign, coalition forces examined all the forward bunkers within the occupied portion of Iraq, essentially south from the Euphrates River. These were the bunkers that housed Iraqi troops, conventional munitions, and other stores of supplies; if chemical munitions had been deployed forward, it is likely they would have been present when the ground war occurred, and overrun by coalition forces. No quantities of

chemical munitions of any type were found. There were also no Iraqi chemical mines encountered, either during the hostilities or during the extensive postwar cleanup. The fact that no chemical munitions have been discovered is the most compelling evidence that, for whatever reason, Iraq did not have chemical weapons deployed to forward positions in preparation for use at the time of the land war. Chemical weapons were present in rear storage areas nearer the production facilities.

The conclusion that there were not chemical weapons directly in the war zone is compatible with other, more indirect, evidence from interviews of Iraqi troops although this source must, for obvious reasons, be considered uncertain in their reliability and their relevance to the entire period of U.S. presence in northern Saudi Arabia preceding the land war. The subsequent Iraqi declarations to the UN inspection teams after the land war had ended also did not indicate that there were chemical weapons directly in the war zone.

A number of pieces of information--satellite photographs, other intelligence information, on-site ground assessment by U.S. forces during and at the conclusion of the land war, and inspection by UN teams that included US personnel--located the area in which chemical weapons may have been stored closest to coalition forces as being in the general vicinity of An Nasiriyah. (3058N:04611E) Some of the bunkers in this general area were identified as possibly containing chemical or biological munitions, primarily on the basis of their characteristic structure. Bunkers in a storage area at An Nasiriyah were first targeted on January 17, the first day of the air war (and later, on January 30 and February 1); those at Talil airbase on February 19. These bunkers suffered varying degrees of damage, confirmed by aerial imagery. There were also reports of damage by the United Nations Special Commission inspection team that visited a different location in the general vicinity of An Nasiriyah several months after the cessation of hostilities. There are indications that the site visited by the UNSCOM team was not a site targeted during the air war but may have been specially constructed for the UN inspectors.

It is unclear what quantities, if any, and types of chemical warfare agent may have been released during these attacks. Detailed assessment of damage was difficult. It is, however, relevant that when the bombs penetrated the bunkers and exploded, they often did not produce massive explosions that could have scattered and disrupted the contents of the bunker. Rather, photo reconnaissance indicated that damage ranged from a single hole in the bunker (from bomb entry) with no other apparent damage, to major structural damage with the roof slab broken in several places and collapsed.

Release of chemical agents from these damaged bunkers would have resulted from damage to the munitions in the bunkers and then escape of the chemical agents as vapors. It is difficult to model the disruption of munitions in bunkers, but given the relatively low vapor pressures of the agents, the uncertainties in the extent of damage inside the bunkers, and the apparent absence

of factors that might have accelerated the escape of the chemicals (such as large secondary explosions or fires that would have destroyed the chemical agents which are organic compounds), escape of agents would have occurred slowly (if at all) over an interval of time (probably days to weeks) rather than as a point event.

There are three sites that may have stored chemical munitions in the vicinity of An Nasiriyah. The indication is that UN inspectors were taken to a separate site that was not bombed.

An Nasiriyah. The extent of damage to An Nasiriyah, and when it actually occurred, due to the bombing is not completely clear: imagery shows only one of the possible CBW bunkers was hit on the January 17, with minor damage. Eventually all the bunkers were destroyed, but it is unclear whether any contained chemical munitions.

The storage facility near the airbase at Talil. Talil was a major airbase, and associated with it was an extensive complex of bunkers for the storage of supplies and munitions. Reconnaissance identified several bunkers as possible sites for storage of chemical and biological weapons, based on observations of the use of bunkers with similar characteristics during the war with Iran. At least some of these bunkers were hit during the air bombardment. If any chemical munitions were stored in these bunkers, any release of chemical agents was not relevant to the reported responses of the Czech detectors, as the bombing of the Talil bunkers occurred much later in the war.

The site visited by the UN inspection team. Several months after the end of the war, a UN inspection team visited a site in the general area of An Nasiriyah. It appeared this was a separate site constructed by Iraq after the war to show to the UN inspectors. The Iraqis claimed that munitions containing 16 tons of Sarin were destroyed in the bombing (a number in agreement with the complete destruction of the rockets in the bunker). There was also some indication that the munitions were only destroyed subsequent to the ground war by the Iraqis. The uncertainty stems from the fact that it is not clear whether the site the UN inspection team was shown was in fact this subject of bomb damage.

Probably the most compelling evidence against a large release of chemical agents from these sites is the absence of any reports of casualties among Iraqi personnel, or at other Iraqi chemical weapons sites that were attacked during the air war. Neither reconnaissance evidence nor interviews with Iraqis after the war indicated that there had been casualties from escape of chemical agents from bunkers damaged at these sites. Examination of the damage around Muthanna (the central Iraqi chemical weapons production facility) after the war, and interviews with local personnel, also indicated that there were not extensive local casualties following damage to this site. This evidence that venting of chemical

agents from damaged bunkers was at a low level, even locally, is important. For there to have been significant exposure to U.S. forces located approximately 200 km from An Nasiriyah, there would have been a very large release at the source. There is no evidence that such a point release occurred.

### What level of exposure would have been detected locally?

#### Sensitivities and Detector Networks.

During the period from the beginning of the air war to the end of the ground war, there were a number of alarms from U.S. chemical agent detectors. (Appendix B contains a timeline that highlights some of these) None of these alarms were confirmed as valid: all were concluded to be false alarms. This conclusion was also reached by other nations in the coalition forces.

There were, however, a small number of events that might, somewhat ambiguously, have resulted from the presence of chemical agents--

-several claims of detections of chemical agents by Czech detection units. The equipment and mobile laboratory are now being evaluated at Edgewood Arsenal.

-a description by a French officer to Senator Shelby of a possible detection event. Information from the French has been sparse, and it has been difficult to learn what they actually detected or how reliable their information is.

-In addition, there was almost certainly an exposure of a U.S. soldier to mustard during inspection of empty bunkers after the end of the war.

None of these claims of detection have been confirmed. These events are described below in greater detail. The absence of confirmed detections of chemical agents by U.S. forces lead to the conclusion no exposure to chemical agents by US forces occurred, as any hypothesis that some troops were exposed to levels less than those detectable by US detectors and such that casualties would have been suffered from chemical agents.

Interpreting the conclusion that there was no *detectable* exposure to chemical agents requires both understanding the structure of the U.S. system for detection of chemical agents, the distribution, reliability and sensitivity of the detectors that form this system, and the protocols followed in the use of the system. U.S. forces are equipped at various levels with detectors that serve different purposes, and have inherent sensitivities and specificities.

#### 4. *Liquid Chemical Agent Detectors*

Table 17

Liquid Chemical Agent Detector Characteristics

Item	Agents	Sensitivity *	Response Time	Basis of Issue (Army)
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M8 Paper	V,G,L,HD, HN,CX	0.02 ml drops	<=30 sec	1/soldier
M9 Paper	All liquid agents	100 micron droplet	<=20 sec	1/soldier
MM-1 (in FOX NBC Reconnaissance System)	Multiple	0.1-100 ug	<=45 sec	6/Army division (10 w/USMC)
M272 Kit	AC HD,L G,V	20 mg/l 2.0 mg/l 0.02 mg/l	6 min 7 min 7 min	Specialized teams in Medical, Engineer, Quartermaster and Chemical units

\* *The quantitative units used for each device vary due to method of use and design specification.*

The most widely available detectors are treated papers (M8 and M9) that are sensitive to droplets of liquid chemical agents. These papers were distributed to individual level, and are worn attached to clothing or equipment (M9), or are used to investigate surfaces suspected of being contaminated (M8). These papers are intended only to provide indication of the presence of a liquid chemical agent hazard, either after receiving a suspected chemical attack, or when entering an area of suspected contamination. They are inexpensive and effective for an individual to determine if there is a liquid chemical agent hazard present, but they are not highly specific for chemical agents. They can respond to other organic substances, such as brake fluid. Users are trained to avoid placing the paper in contact with other substances known to cause false readings, and to consider other possible indicators of chemical agent presence when assessing a positive reaction of the paper.

A specialized kit that was fielded to units responsible for fresh-water handling, the M272 kit can detect the presence of chemical agents in water. If a supply of water is suspected of being contaminated, because the water source has been in the area of a chemical attack or if it has flowed through an area of contamination, this device would be used to ensure the safety of the drinking water.

The FOX NBC (Nuclear, Biological and Chemical) Reconnaissance System is a wheeled, armored vehicle equipped with an on board mass spectrometer for the identification of chemical contamination. Sixty FOX systems were given to the US by Germany during Desert Shield; 50 went to Army units, and 10 to US Marine Corps forces. The FOX was designed to locate and mark the presence and extent of liquid chemical agent contamination. Two sampling wheels mounted on the rear of the vehicle roll on the ground, and are lifted up and "sniffed" by the sampling probe at intervals. The FOXs, operated by specially trained chemical specialists, were called on, if located nearby, to confirm possible or suspected chemical agent detections.

##### 5. Vapor Chemical Agent Detectors

**Table 18**  
**Vapor Chemical Agent Detector Characteristics**

Item	Agents	Sensitivity	Response Time	Basis of Issue (Army)
M8A1 Alarm	G, V nerve	0.1-0.2 mg/m <sup>3</sup>	<=2 min	5/ company
M256A1 Kit	G V H L CX CK AC	0.005 mg/m <sup>3</sup> 0.02 mg/m <sup>3</sup> 2 mg/m <sup>3</sup> 9 mg/m <sup>3</sup> 3 mg/m <sup>3</sup> 8 mg/m <sup>3</sup> 9 mg/m <sup>3</sup>	15 min 15 min 15 min 15 min 15 min 15 min 25 min	1/squad
CAM	GA, GB, VX, HD, HN	<=0.1 mg/m <sup>3</sup>	<= 1 min	2/company
M18A2 Kit	GB CG HD L AC	0.1 & 1.0 mg/m <sup>3</sup> 12.0 mg/m <sup>3</sup> 0.5 mg/m <sup>3</sup> 10 mg/m <sup>3</sup> 8 mg/m <sup>3</sup>	NA	1/Explosive Ordnance Disposal team
MM-1 (in FOX NBC Recon System)	CG CK GB	115 mg/m <sup>3</sup> 46 mg/m <sup>3</sup> 62 mg/m <sup>3</sup>	<=45 sec	6/Army Division (10 w/USMC)

The most widely available detector for determining the presence of chemical agent vapors is the M256A1 Chemical Agent Detector Kit. These kits contain vials of liquid chemical reagents that are combined and exposed to the air in a specific sequence to indicate the presence of hazardous levels of chemical agent vapors. The kits must be manually manipulated, and the full sequence of tests takes 20-25 minutes; consequently, these are not used for monitoring or warning of personnel. Rather, these devices are used by trained personnel after a unit has entered full protective posture, to determine if a hazard actually exists in the immediate area, and to assist the local commander in initiating un-masking procedures if there is no indication of hazard. These kits are more sensitive for nerve agent than the automatic alarm, and are not sensitive to the same type of interferences that can cause false alarms. Approximately 45,000 of these detector kits (each of which contains 12 actual detector packets) were deployed in the Gulf.

The M8A1 Automatic Chemical Agent Alarm electronically monitors for hazardous levels of nerve agent vapor. Once placed into operation, it will run for up to 24 hours before needing servicing. The detector component of this system can be displaced upwind from the unit's position and connected by wire to an audible and visible alarm module. Units use this device when in stationary positions; it cannot generally be operated while on the move. While sensitive, this device is also prone to false positive responses under some conditions due to high concentrations of certain organic compounds (some pesticides, vehicle exhausts, rocket smoke) and troops are trained to use care in emplacing the device to minimize the chance of false alarms.

Although it detects vapors, in actual practice the Chemical Agent Monitor (CAM) serves as a post-attack device for determining the presence of vapors emanating from localized liquid contamination. This hand-held air sampler detects and identifies nerve and blister agent vapors, and depicts in a rough quantitative form on a bar-graph display, the degree of contamination.

Although sensitive and specific for identification of ground contamination, the mass spectrometer system on board the FOX is not optimized for sampling and alerting to generalized airborne vapors of chemical materials. When operating in the air sampling mode, the FOX is not a suitable warning device; very high concentrations of chemical agents would have to be present, such that unprotected troops in the vicinity would be adversely and acutely affected.

The confirmation of the presence of a chemical agent requires examination by a second detector, one using a different principle of operation. For final field verification of the presence of chemical agent, the FOX was the item of choice. In practice, none of the preliminary alerts for possible presence of chemical agents reported or investigated by U.S. forces were confirmed as valid. Consistent with the experience of other coalition partners, this conclusion confirms that there were no exposures at levels high enough to trigger U.S. alarms. It does not, by itself, rule out the possibility of exposures below the threshold of U.S. detectors, although such exposure could not occur without detectors located upwind having positive and confirmed responses and possible physiological signs from chemical agent exposure at these higher levels.

The highest level of chemical agent to which U. S. personnel could have been exposed without triggering an alarm is determined by the threshold sensitivity of the detectors. On the basis of detector specifications, the highest concentration to which U.S. personnel could have been exposed was 0.2 mg/m<sup>3</sup> of nerve agent, and 2 mg/m<sup>3</sup> of mustard.

#### **Possible Detection Incidents: A Mustard-contaminated Bunker near Basra.**

The incident that provides the most probable case of exposure of an American soldier to a chemical agent was an accidental exposure that occurred while inspecting bunkers in southern Iraq after the conclusion of the ground war. The soldier entered a number of bunkers while performing his mission to locate enemy equipment, personnel or intelligence material. Approximately 8 hours later, he experienced skin irritation and reddening. After 8 more hours, he presented to unit medical personnel with erythema and two small (1-2 cm) blisters on one arm consistent with a mustard exposure. A FOX vehicle was called to determine if the soldier's clothing was contaminated; it initially identified HQ mustard. The following day, two FOXs were called in to confirm the reading; of the two FOXs present on this occasion, only one could get a reading, but this time of HD mustard. The FOX teams were not able to find contamination in any of the bunkers entered by the soldier.

Several other scientific findings confound this story, however. When the soldier's clothing was shipped back to the US for subsequent examination under laboratory conditions, no traces of mustard or its highly stable degradation products were found. Additionally, urine samples taken from the soldier were negative for the presence of thiodiglycol, a metabolite typically observed from exposure victims. Nevertheless, based on the symptoms shown by the soldier, and on the positive identification by one FOX, it seems plausible that this soldier was, in fact, exposed to mustard. As an apparently singular event, however, it carries no implication of a mechanism for exposure of a significant number of other U.S. personnel.

#### **Possible Detection Incidents: Czech Announcements of Detection.**

The announcement in the summer of 1993, following US media and Congressional interest in whether there were unexplained health effects in Gulf War participants, that Czech chemical detection units had reported that their detectors had responded in three separate incidents during the beginning of the air war, attracted substantial attention. These reports were the only ones that seemed to provide any support to the idea that there might have been any chemical agents in the regions occupied by U.S. forces, and that these agents might have originated in bunkers damaged during the bombings.

Examination of the Czech reports indicates that the accuracy of their detection is still uncertain and that there are a number of internal inconsistencies in the available information. It is not clear that any of the incidents described by the Czechs unambiguously identified chemical agents, and the origin of the materials sampled is even more uncertain.

The important incidents surrounding the Czech detections are listed below in boldface; associated, relevant events are also included in this list. A map of Saudi Arabia at Appendix E.

- **Jan. 17: Bombing of An Nasiriyah**
- **Jan. 18: Hussein announced on CNN that he had chemical weapons; tension increased on the subject of chemical weapons.**
- **Jan. 19: A Czech unit reported nerve agent at the Engineering School at KKMC. An attempt at confirmation by U.S. personnel failed. (CENTCOM log)**
- **Jan. 19: French and Czech units report nerve agent 30 km from KKMC in two separate incidents.**
- **Jan. 20: Czechs detect low levels of mustard vapor near the Engineering School in KKMC for 2 hr.**
- **Jan. 20: Czechs report a small patch of nerve agent: U.S. examination does not confirm.**
- **Jan. 24: Czechs are directed to a puddle of mustard by Saudis. Not in any available log.**
- **Feb. 9: Bombing of storage bunkers at Talil airfield.**



These incidents can be broken into two sets: the cluster of reports of nerve agents by Czech units in the three days (Jan 18 - Jan 20) following the bombing of An Nasiriyah on Jan 17, and the examination of the puddle of mustard on the 24th. The date of another possible release--the bombing of a bunker at Talil--is also included for comparison, although there were no alarms following this event and it occurred much later in the air war.

*Czech and French reports in the Interval January 17 - 20.* These events were in a time period when it might, in principle, have been possible for them to reflect venting from a bunker or bunkers at An Nasiriyah. Because of the uncertainties in the estimates of damage at An Nasiriyah, it is only possible to provide an upper limit to the possible release of nerve agents. If it is assumed that one bunker was destroyed, that the bunker had contained chemical agents and that an estimate of 16 tons of sarin being contained in a single bunker is correct, then the maximum release of nerve agent that could have occurred on the 17th was 16 tons. In fact, the total amount would have been less, since the venting would occur slowly, and all the chemical agent in the chemical rounds in the bunker would not actually be released.

On January 17 and 18--the days immediately following the bombing of An Nasiriyah--the weather conditions were unfavorable for movement of vented material toward the coalition forces: On the 18th it rained all day, and the wind was from the Southeast (that is, from Saudi Arabia into Iraq). Due to the high solubility of Sarin in water (21 g/L) rain would have significantly reduced the concentration of Sarin vapor. On the 19th the wind began to shift to the northwest, but there was an occluded front over the region in question. The microclimate was variable, and the Czech report of local winds from the northwest in the wadi in which they were traveling is believable, but probably not relevant to movement of a plume from An Nasiriyah toward U.S. forces.

*The mustard puddle on January 24.* This event occurred too late to be associated with the bombing on the 17th. Saudi personnel *directed* the Czech unit to a puddle of damp ground in a remote area, and asked them to investigate. The Czechs detected mustard. No effort was made to confirm the identity of the material, nor were soil samples taken for laboratory confirmation. This peculiar event may have been some type of test or training exercise by the Saudis, although no confirmation of this hypothesis has been received from them.

### **Other Incidents.**

There were a number of other observations and events reported as evidence of use of chemical weapons. Appendix B lists a number of these. Here we describe four, with the purpose of showing how combinations of anxiety, inexperience with equipment or unfamiliarity with the local environment generated confusion about the presence of chemical weapons.

*Event near Al Jubayl.* On January 20, members of 24th Naval Reserve Construction Battalion (Seabees) were awakened from sleep by a loud noise. They moved to bunkers and donned protective masks. Tests for chemical agents were negative. Recent reports by members of this group, describing a strong ammonia smell and burning skin was not corroborated by log entries. An adjacent unit described a sonic boom at roughly the same time, but no other unusual events.

*"Purple Tee-Shirts".* Members of the same Seabee unit reported an event in which a distant noise, a "mist" and a smell of ammonia were accompanied, subsequently, by sections (especially in the area of the armpits) of the brown tee-shirts worn by some personnel turning purple. There were no symptoms of chemical toxicity. This configuration of events was interpreted by some of those involved as evidence of attack by a rocket with a chemical warhead. There was no evidence to support this interpretation.

An analysis of dye chemistry, and of several tee-shirt samples obtained from the unit, conducted by the Natick Research, Development and Engineering Center concluded that the probable cause of the color change was exposure to nitric or nitrous oxide fumes.<sup>3</sup> These materials may have been present in the industrial area in which the Navy unit was billeted. Tests using a wide range of industrial acids, bases and oxidizers were used to determine dye reaction; it is interesting to note that exposure to ammonia did not elicit a color change. Past records from agent challenge tests to clothing materials, conducted at Dugway Proving Ground, indicate no color change associated with any chemical agent test.

Although the details of the events contributing to the incident are still not clear, it is probable that exposure to a release of some industrial chemical or to perspiration (or some combination of these factors) was the factor underlying the color changes.

*"Lewisite Detection".* On February 26, during the ground war, a FOX operated by Marines operating along the Saudi Arabia/Kuwait border alerted to Lewisite; reexamination with the M256A1 kit failed to confirm this detection. Lewisite was not in the Iraqi inventory. The mass spectrometer on the FOX operates by drawing a sample from the exterior through a silicone membrane into the inlet of the mass spectrometer. The FOX involved in this incident was operating with a new membrane, and with a crew that had only recently completed training. The mass spectrometric signature of Lewisite is similar to that of silicone plasticizers used in the membrane. This incident thus probably reflects a

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<sup>3</sup>Color Changes of T-Shirts Worn During Operation Desert Shield/Storm, Letter Report, Natick Research, Development and Engineering Center, 17 May 1994.

misinterpretation of a confusing signal, resulting from the leakage of silicone plasticizer from the new membrane.

*"Dead Animals along the Road."* U.S. forces noted the presence of numbers of dead animals along the sides of the roads in certain areas, and were concerned that these animals had died by exposure to chemical or biological agents. The animals were certainly present, but the interpretation of their presence requires an understanding of the Saudi Arabian agricultural system. When valuable domesticated animals--sheep, goats, camels--die in Saudi Arabia, the carcass is moved to a nearby road. Collecting the remains along the roads has two purposes: to allow the local administrators to verify the deaths (in order to compensate the owner for the losses), and, in some cases, to help the local agricultural officers or veterinary personnel to inspect or sample the carcasses to help establish the cause of death. No information was presented that would indicate that the circumstances surrounding the dead animals were related to chemical or biological agents.

#### **Could Chemical Agents Released on Bombing the Storage Sites in the Vicinity of An Nasiriyah Have Exposed U.S. Forces?**

Since these sites were suspected at the time to have chemical weapons, and since they were the closest such sites to U.S. and coalition forces, the circumstances surrounding their bombing has been examined to detail to see if they could be the source of the chemical agents detected by the Czech units, or if there might otherwise plausibly be a source of low-level exposure of U.S. personnel.

Modeling performed by the Defense Nuclear Agency using the ANBACIS (Automated Nuclear, Biological and Chemical Information System) II computer program demonstrates that the maximum extent to which a lethal concentration (LCt 50: lethal to 50% of exposed personnel) would travel would be 8.7 km. Incapacitating effects would be expected out to 9.3 km. Similar examinations of the other southernmost suspected chemical storage bunkers resulted in similar hazard distances. No cases resulted in any hazard areas coming within 150 km of any US or other coalition forces. These estimates are very similar to the results of an unpublished CBDE Porton Down Report dated September 1992, which detailed UK studies on the potential effects of bombing Iraqi CBW production and storage sites.

Several lines of evidence indicate that it is improbable that any release of chemical warfare agents at An Nasiriyah is connected to Czech detections (with the obvious further caution that the Czech detections themselves remain suspect, pending checks on the performance of their equipment and resolution of inconsistencies in accounts by Czech personal of equipment and procedures).

- *Extent of Damage at An Nasiriyah.* If chemical munitions were stored at An Nasiriyah and if a bunker containing chemical munitions was hit, then a

plausible upper limit to the amount of nerve agent in such a bunker would be 16 tons; in practice, the amount released would be much less. Plausible amounts of vented material are too low to have traveled the 150 - 200 km to the Czech units in detectable concentrations.

- Apparent Absence of Other Casualties in the Vicinity of An Nasiriyah. To have a detectable amount of nerve agent in Saudi Arabia, there would have had to have been a large release in An Nasiriyah. A large release should have produced local casualties. None apparently occurred. The inference that any release was small, even at the source, is confirmed by observations after a later bombing at Talil, and by bombings at Muthanna.

- Weather. The weather was unfavorable for movement of nerve agent toward coalition forces: the wind measured at Hafir al Batin between the 17th and the 19th was from the south-southwest, then southeast on the 17th; from the east-southeast on the 18th with rain; from the east-southeast in the morning of the 19th, changing to from the north-northeast with the passage of a weather front.

- Plume Analysis. Mathematical modeling of the plume from a release suggests that a larger quantity than could have plausibly been released would have been required to reach the Czech forces in detectable amounts. The task force was briefed that under best case weather conditions, 80-100 tons of agent instantaneously released could have resulted in the concentrations described by the Czechs.<sup>4</sup>

The conclusion from these considerations is that it is very unlikely that the Czech units detected nerve agent released on bombing An Nasiriyah.

This same analysis shows that, regardless of the truth of the Czech reports, bombing the sites around An Nasiriyah was not likely to be a more general source of significant exposure of U.S. forces. If the Czech detections were correct, and if they were detecting chemicals vented from An Nasiriyah (both substantial "ifs"), the plume would have had to be relatively sharply defined (another conclusion that is difficult to believe, given the variability of the wind direction and the weather in this period). A sharply defined plume that coincidentally reached the Czech units would not have covered a significant area of the front, and would not have exposed many U.S. personnel.

#### **More Distant Storage Sites.**

Chemical weapons were also present at several sites in central Iraq (Al Habbaniyah, Karbala, Samarra). In the period leading up to Desert Storm, some

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<sup>4</sup>Plume Modeling briefing to DSB Task Force, McNalley R.

chemical munitions were dispersed from the manufacturing and filling site at Muthanna to these storage sites . The distances of these other sites from the area of operations in the theater precludes them as a source of chemical exposure to U.S. forces. Dilution in the air of agents released in bombing the sites, and the effects of atmospheric turbulence and rain make it impossible for these more distant sites to have acted as significant sources of exposure.

**Conclusions.** The conclusion from this analysis is that U.S. personnel were not exposed to any significant levels of chemical or biological agents during the Gulf war. A summary of the evidence and inferences follow:

- There was no evidence of the deployment or use of biological weapons in the Gulf theater. Recognition of an infectious agent such as anthrax is straightforward, and no cases of anthrax were detected in U.S. forces. The symptoms of exposure to botulinum toxin, and of other biological warfare agents, are also well understood, and were not detected.
- There were no overt, intentional uses of chemical weapons by Iraq. This conclusion is confirmed by other members of the coalition, and by senior Iraqi officers.
- There were either no, or essentially no, chemical munitions deployed forward by Iraq. The absence of chemical weapons makes it impossible that there could have been unauthorized or accidental use by local commanders, and also indicates that release from forward bunkers during bombardment is not a credible source of chemical exposure to U.S. forces.
- The most plausible potential source of chemical exposure was damage to bunkers at An Nasiriyah if these bunkers contained chemical weapons. An Nasiriyah was separated from the nearest U.S. forces (with the possible exception of special operations forces) by a minimum of approximately 150 km. When An Nasiriyah was bombed, the plausible quantities of nerve agent released and the weather combine to make it very unlikely that it could have been the source of the Czech detections, or of more general exposure of U.S. personnel. Other possible sources of chemical agents released on bombardment (such as Muthanna) were too far away to provide significant exposure.
- The absence of local casualties at An Nasiriyah, Muthanna and Talil suggest that even when bunkers which might have contained chemical weapons were bombed, the rate and extent of release did not pose a great risk even to those in the immediate vicinity.

- The Czech claims of detection--the only reports that seemed to lend some credibility to the idea of exposure of some type--are themselves clouded by a number of peculiarities and internal inconsistencies. These reports cannot be confirmed or dismissed until the evaluation of the Czech detection system now in progress at Edgewood is complete.

- The one plausible injury of a U.S. soldier by a chemical agent occurred after the end of the ground war, and originated during inspection and demolition of Iraqi bunkers. It seemed to be the result of accidental contact of the soldier with contaminated soil in a bunker that may have been used previously (probably during the Iran/Iraq war) for storing mustard.

- In the absence of confirmation of the Czech reports, there are no data suggesting exposure of U.S. personnel to chemical weapons. The threshold sensitivity of U.S. detectors was approximately  $0.05 \text{ mg m}^3$  and while levels lower than this cannot be excluded on the basis of physical measurement, the absence of any credible source of exposure makes it unlikely that there was any level of exposure.

## VII. LONG TERM EFFECTS OF LOW-LEVEL EXPOSURE TO CHEMICAL AGENTS

This section discusses what is known about the long-term effects of exposure to low-levels of chemical warfare agents.

During the period from 1958-1975 some 6720 soldiers took part in a voluntary test program of 24 chemical agents conducted by the US Army at the Army Chemical Test Center at Edgewood, Maryland. In 1980, the Department of the Army asked the Committee on Toxicology of the National Research Council's Board on Toxicology and Environmental Health Hazards to study possible chronic or delayed adverse long-term health effects incurred by servicemen who took part in these tests. The terms of reference to the panel were:

1. determine whether the data available were sufficient to estimate the likelihood that the test chemicals have long-term health effects or delayed sequelae
2. determine whether the involved chemicals, as tested, are likely to produce long-term adverse health effects or delayed sequelae in the test subjects.

Their findings were presented in three volumes: Volume I covered anticholinesterase and anticholinergic chemicals; Volume II covered cholinesterase reactivators, psychochemicals, mustard gas and several irritating substances;

Volume III was a follow-up report on the current (as of 1985) health of the test subjects.<sup>5</sup>

The panel concluded that although no evidence had been developed that any of the anticholinesterase (anti-ChE) test compounds surveyed carries long-range adverse health effects in the doses used, they were unable to unequivocally rule out the possibility that some anti-ChE agents produced long-term adverse health effects in some individuals. While exposures to low doses of organophosphate compounds had been reported in the research literature (but not confirmed) to produce subtle changes in EEGs; sleep patterns, and behavior that persisted for up to a year, such effects were not known or reported for the Edgewood cohorts.

There was no firm evidence that any of the anticholinergic test compounds tested produced long-range adverse human health effects in the doses used in the Edgewood tests. However, the high frequency of uncontrolled test variables made evaluation of behavioral effects difficult. The panel concluded that given the available data, it was unlikely that administration of these anticholinergic compounds will have long-term toxicity effects or delayed sequelae. For both the anti-ChE and anticholinergic test subjects, mortality rates were not significantly higher than those for the US population, categorized by age and calendar year.

There was no evidence of chronic disease associated with single or repeated doses of the cholinesterase reactivators; however, lack of follow-up data on the volunteers and the absence of conclusive studies precluded any conclusions regarding the carcinogenicity, mutagenicity or reproductive anomalies that might be associated with these agents.

Mustard gas has known carcinogenicity and mutagenicity at high, long term dosages, but the effects are unknown for low dose exposures.

A follow-up study in 1985 based on a mailed questionnaire concluded that there were no significant long-term effects of any kind or occurrence of clustering of physiological problems that could distinguish the test group exposed to agents from those not exposed, or from the general population. The conclusions were based on responses by 4085 of the 6720 persons tested. The questionnaire was supplemented by a review of VA hospital admissions records of the test subjects, specifically for malignant neoplasms, for mental disorders, and for diseases of the nervous system and sense organs. Study of admission statistics showed no significant admission for these categories than the unexposed baseline test population.

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<sup>5</sup> Possible Long Term Health Effects of Short Term Exposure to Chemical Agents, Vols. I, II, and III, Committee on Toxicology, Board on Toxicology and Environmental Health Hazards, Commission on Life Sciences, National Research Council, National Academy Press, Washington DC, Vol I-1982, Vol II-1984, and Vol III-1985

A more recent study by Sidell and Hurst<sup>6</sup> updates the NRC study and is supported by 124 references. The report summarizes historical data on single or repeated acute doses of nerve agents or mustard. The report implicates nerve agents and mustard as the cause or probable cause of several long-term health effects. Repeated symptomatic exposures to mustard seem well established as a causal factor in airway cancer. Delayed keratitis has appeared more than 25 years after acute severe lesion due to mustard; pigment changes and skin cancer also have been observed as delayed sequelae at the site of mustard-induced lesions. While the production of non-airway cancer by mustard has been observed in animals, there is little evidence to implicate mustard as the causal agent for non-airway cancer in humans. Despite unequivocal laboratory evidence of, and its classification as a mutagen, there seem to be no definitive data to implicate mustard as a reproductive toxicant in man.

Regarding nerve agents, Sidell and Hurst make the point that while nerve agents and insecticides are both organophosphates, their effects are distinct and differ in their duration. Cholinergic intoxication due to nerve agents lasts for hours, while that from insecticides may persist for weeks. Some pesticides do not cause polyneuropathy, though others have been shown to do so in animals at sub-lethal doses; nerve agents cause polyneuropathy only at doses many times the LD<sub>50</sub>, requiring extreme intervention to keep the animal alive to observe the effect. Exposure to insecticides has also been shown to express as an "intermediate syndrome" -- that is, intermediate between acute cholinergic effects and delayed neuropathy. Intermediate syndrome has not been described after exposure to nerve agents. Psychological problems, sleep disturbance, and psychomotor difficulties appear with varying degrees of persistence after insecticide exposure.

In its 1993 report<sup>7</sup>, the Institute of Medicine found a causal relationship between substantial exposure to Mustard or Lewisite and a number of conditions including respiratory and skin cancers, skin pigmentation abnormalities, chronic skin ulceration, chronic respiratory diseases, chronic conjunctivitis, delayed recurrent keratitis of the eye, bone marrow and immunosuppression, psychological disorders, and sexual dysfunction. It reported insufficient information to demonstrate causal relationship between exposure and gastrointestinal, hematological, neurological and cardiovascular diseases.

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<sup>6</sup> The Long-Term Health Effects of Nerve Agents and Mustard, F.R. Sidell and C.G. Hurst, US Army Medical Research Institute of Chemical Defense, APG, MD, 1993.

<sup>7</sup> Veterans at Risk, CM. Pechura and D.B. Rall, editors, National Academy Press, Washington, DC, 1993.



## VIII. PROPOSED EXPOSURE ETIOLOGIES

### **A. Chemical Warfare Agents**

As discussed in sections VI and VII above, there is no evidence that either high or low levels of exposure of US troops to chemical agents occurred, and there is no indication from research that there would be chronic sequelae from low level exposure even if it had occurred.

### **B. Biological Agents**

While Iraq has been assessed as having had an active offensive BW program, there is no evidence for the deployment of BW during ODS. The diseases associated with BW agents, e.g., anthrax, botulinum, etc., are notable for acute effects and would have been rapidly evident and readily diagnosed had they occurred among US or coalition troops during the war.

## C. Infectious Disease

By any previous standards, casualties from infectious diseases were extremely low during Desert Shield/Desert Storm, reflecting effective application of preventive medicine doctrine and good discipline. Food and water-borne diseases and vector borne diseases have, in the past, caused very high casualties to armies in that region. The major causes of morbidity from infectious diseases were self-limiting diarrhea and respiratory illnesses. Low overall enteric disease rates testify to safe food supplies and food preparation and effective water purification methods. The virtual absence of vector-borne viral diseases such as sandfly fever and only 7 cases of malaria appear to be the result of a combination of vector control, personal protection, and climatic factors.<sup>8,9</sup>

### 1. Insect-borne

One vector-borne parasitic disease, leishmaniasis, has been suggested as a potential cause in later development of chronic unexplained illness.<sup>10</sup> The leishmania species present in the theater can cause self limiting skin infections (cutaneous leishmaniasis), severe visceral disease (kala azar) and, a chronic disseminated infection without obvious skin lesions or major organ involvement.

Thirty-one cases of leishmaniasis contracted in the theater have been diagnosed in military personnel. Nineteen cases were cutaneous disease and 12 were disseminated disease. Clinical and parasitologic studies by Army investigators have defined the spectrum of illnesses caused by *Leishmania tropica*, the predominate Leishmania species in the region. The cases of disseminated viscerotropic illnesses caused by this species was a surprising new observation leading to the hypothesis that there may be additional cases of cryptic infections causing chronic illness that cannot be diagnosed by current parasite isolation or serologic methods.

There was some evidence for clustering of leishmaniasis cases in units -- not unexpected since transmission is by sandfly vectors. The reported studies are clinical, parasitologic and immunologic studies and do not address the epidemiology of the disease in DS/DS. Also lacking are data on the distribution of sandfly vectors in the theater, although information presented by a Navy entomologist with the

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<sup>8</sup>Richards AL, Malone JD, Sheris S, et al. Arbovirus and rickettsial infections among combat troops during Operation Desert Shield/Desert Storm. *J Infect Dis* 1993;168:1080-1081.

<sup>9</sup>Richards AL, Hyams KC, Merrell BR, et al. Medical aspects of Operation Desert Storm. *N Engl J Med* 1991; 325:970.

<sup>10</sup>Macgill AJ, Grogg M, Gasser RA, Sun W, Oster CN. Visceral infection caused by *Leishmania Tropica* in veterans of Operation Desert Storm, *N Engl J Med* 1993; 328:1383-1387.

DoD Pest Control Board indicated that some surveys had found very little evidence for large numbers of the sandfly in areas of high troop concentrations.<sup>11</sup>

A possible role for leishmaniasis in later unexplained illness has been suggested, but additional studies are warranted to rule out such chronic infections which result in very little antibody and are difficult to diagnose. Development of more sensitive and less invasive diagnostic methods is an important research effort that will help to define the full extent of disease due to leishmania parasites and determine whether Leishmaniasis is a significant contributor to the chronic unexplained illness. The lack of outbreaks of sandfly fever probably indicates a low overall exposure to sandfly bites. A comprehensive epidemiologic study, however, should include a study of the distribution of leishmaniasis cases.

## 2. *Food Borne*

Contaminated lettuce from local vendors was described as having led to outbreaks of diarrhea.<sup>12</sup> Additionally, although standard sanitary practices were in place, it is probable that some of the incidence of diarrheal disease was related to contaminated water, foods or utensils. *Giardia lamblia* can be a cause of prolonged, watery diarrhea in veterans returning from areas where the water supply has been contaminated, although the task force did not receive information that this had been noted through surveillance of Gulf War veterans.

## 3. *Respiratory*

There were many instances of respiratory ailments beginning, or being aggravated by the living and working conditions for troops in Saudi Arabia. In one instance, troops occupying a long-vacant Saudi housing area in Al Eskan experienced significant rates of respiratory disease due to the fine sand and dust from accumulated pigeon droppings.<sup>13</sup> The disease was described as self-limiting, and while it is possible that some individuals who experienced this condition may have developed chronic sequelae, the extent of the conditions precipitating these cases does not provide an explanation for most of the veterans with undiagnosed medical complaints.

## D. *Environmental/Occupational Pollutants*

The very nature of warfare exposes combatants to a variety of hazardous substances, not the least of which is flying steel, shrapnel and blast overpressures

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<sup>11</sup>DoD Pest Management Board, briefing to DSB Task Force, February 8, 1994.

<sup>12</sup>Korenyi-Both AL, Molnar AC. Al Eskan Disease: Desert Storm Pneumonitis. *Mil Med* 1992; 157: 455.

<sup>13</sup>Korenyi-Both AL, Molnar AC. Al Eskan Disease: Desert Storm Pneumonitis. *Mil Med* 1992; 157: 452-461.

from conventional warfare munitions. Most exposures during the Desert Shield/Storm time frame involved materials of lesser toxicity. Several situations of note included exposures to petroleum products, pesticides and CARC (Chemical Agent Resistant Coating) paint.

1. *Petroleum Products*

While a wide variety of fuels, lubricants and solvents were present routinely in many situations during the operation, it is not clear that exposures were different than soldiers encounter during peacetime military operations and training.

2. *Alcohol Substitutes*

No inquiry has been made on the extent of substance abuse (e.g., solvent sniffing, etc.) in a population that was abruptly deprived of alcohol. Some troops in the Vietnam war are known to have injured themselves by ingesting RDX, a plastic explosive, and a small number of individuals are bound to have experimented with these and other substances.

3. *Insecticides*

The Task Force received information<sup>14</sup> regarding the use of pesticides used for vector-borne or rodent disease prevention and control. All such materials used by military are EPA approved, and applied by trained technicians. Relative quantities of pesticides available to deployed units can be deduced from supply records, but application records do not exist.

Common pesticides used included *d*-phenothrin, chlorpyrifos, resmethrin, malathion, methomyl, lindane, pyrethroids and DEET.

There are potential acute adverse effects from pesticide poisoning; organophosphates can cause headache, diarrhea, dizziness, blurred vision, weakness, nausea, cramps, discomfort in the chest, nervousness, sweating, miosis (pinpoint pupils), tearing, salivation, pulmonary edema, uncontrollable muscle twitches, convulsions, coma, and loss of reflexes and sphincter control. Nausea, incoordination, and eye and skin irritation can occur following acute pyrethroid exposure. Polyneuropathy can occur 2-3 weeks following high-level exposure to some organophosphates (malathion, chlorpyrifos).<sup>15</sup>

While some individuals may have experienced some effects from local pesticide use, there were no reports of acute pesticide poisoning during the war. If continued analysis of the VA registry indicates a higher incidence of neurophysical disorders in those veterans whose duties included routine application

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<sup>14</sup>DoD Pest Management Board, briefing to DSB Task Force, February 8, 1994.

<sup>15</sup>Ecobichon DJ, Davies JE, Doull J, et al. Neurotoxic Effects of Pesticides. Advances in Modern Environmental Toxicology, Volume XVIII, Princeton Scientific Publishing Co., Inc, NJ. 131-199.

of pesticides, pesticide exposure may come under closer scrutiny as an etiological factor for other participants.

#### 4. *Oil Well Fires*

On February 23, 1991, Iraqi forces began to destroy and set on fire more than 700 oil wells throughout Kuwait. All the fires were extinguished and the wells were capped by early November, 1991, but there was great concern regarding the potential health risk to personnel in the region as a result of their exposure.

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During the 8 month period in which the oil wells were burning, numerous efforts were undertaken to assess the air quality over Kuwait and to determine the health risks posed to the populations living, working, and serving in the military in the region. The U.S. Interagency Air Quality Assessment team arrived in Kuwait in March 1991 to begin to assess the possible health effects of the smoke from the oil fires. This team was composed of scientists from the U.S. Environmental Protection Agency, the National Oceanographic and Atmospheric Administration, and the Department of Health and Human Services.

During the period of the fires, the measured levels of two major air pollutants (sulfur dioxide, nitrogen dioxide) did not reach harmful levels. The level of particulate matter measuring less than 10 microns (PM<sub>10</sub>), that portion of airborne particulate with the greatest impact on the respiratory system, did exceed the U.S. "alert level" on several occasions. However, Kuwait has frequent sand and dust storms, and the average level of PM<sub>10</sub> in Kuwait is nearly 600 ug/m<sup>3</sup>, the highest in the world.

The hazards to the soldiers posed by the smoke were largely dependent on the concentration of the pollutants in the air near the camps. Fortunately, the plumes resulting from the fires rose up to 10,000 to 12,000 feet, mixing with the air and then being dispersed for several thousand miles downwind over a period of several weeks. As the plume traveled, the particles and gases contained within it became more widely dispersed and also more diluted. The highest concentrations were in the areas nearest the affected oil fields and the areas immediately downwind. Few soldiers were in those areas for long periods of time. Considerable

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<sup>16</sup>Riley JJ, Hicks NG, Thompson TL. Effect of Kuwait oil field fires on human comfort and environment in Jubail, Saudi Arabia. *Internat J Biometeorology* 1992; 36-38.

<sup>17</sup>Ferek RJ, Hobbs PV, Herring JA, Laursen KK, Weiss RA, Rasmussen RA. Chemical composition of emissions from the Kuwait oil fires. *Geophysical Research* 1992; 97: 14483-14489.

<sup>18</sup>Hobbs PV, Radke LF. Airborne studies of the smoke from the Kuwait oil fires. *Science* 1992; 256:987-991.

<sup>19</sup>Laursen KK, Ferek RJ, Hobbs PV, Rasmussen RA. Emission factors for particulates, elemental carbon, and trace gases from the Kuwait oil fires. *Geophys Res* 1992; 97:14491-14497.

dilution took place over space, such that by the time the plume reached areas of troops in Saudi Arabia, it was far less visible and less concentrated than in Kuwait.

Potential effects on the respiratory system, such as a small loss in lung function or the development of chronic bronchitis, would be of particular concern to those who were exposed for many months to severe particulate pollution. These effects might be more likely to occur in cigarette smokers.

The US Army Environmental Hygiene Agency report of its participation in ODS provides some useful insights regarding industrial hygiene, preventive medicine and the impact of oil fires on health issues. The report cites no incidents regarding exposure to chemical weapons agents. Principal USAEHA efforts were to evaluate the health effects risks due to oil fires. On the basis of air and soil pathway analysis, excess cancer risk resulting from exposure to the Persian Gulf environment ranged from 2 to 5 per 10,000,000 well below the EPA range of concern of 1 per 10,000 through 1 per 1,000,000. The cancer risk assessment was based primarily on the risk from chromium. There was little difference in risk levels found between Saudi permanent monitoring sites and those in Kuwait near the oil fires. These results were based on collection of over 4,000 samples at 10 fixed ground sites over a period of seven months beginning in May 1991.<sup>20</sup>

Additionally, the National Center for Environmental Health, Centers for Disease Control and Prevention, performed surveys of VOC (volatile organic compounds) in the whole blood of two groups; American personnel employed in Kuwait City, about 20 km from the burning wells, and firefighters and medical personnel working at the burning oil wells.<sup>21</sup> Concentrations were compared to those of a random sample of persons in the United States. Median concentrations of the first group were equal or lower than those of the reference group; the firefighters did have elevated levels of some VOCs over those of the reference group. Since US military personnel were not involved directly in the fire fighting operations, their exposures would have been more comparable to those study personnel in Kuwait City, who showed no elevation in VOC level.

##### 5. *Sand*

Because many US troops trained, executed maneuvers and actually lived out in the desert, there was initial concern for the possible adverse effects of being exposed to high levels of blowing and suspended sand. The sand was often powdery in consistency, and some personnel with respiratory problems did experience aggravated symptoms. An epidemiologic survey conducted among 2598 men stationed in northern Saudi Arabia, however, found that the type of structure in

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<sup>20</sup>Operation Desert Shield/Desert Storm: History of Participation by the US Army Environmental Hygiene Agency, Aberdeen Proving Ground, MD 7 August 1990 - 31 December 1991.

<sup>21</sup>Etzel RA, Ashley DL; Volatile organic compounds in the blood of persons in Kuwait during the oil fires, *Int Arch Occup Environ Health*, Spring 1994.

which a person slept may have been as important a risk factor for developing respiratory complaints as exposure to outdoor air pollutants.<sup>22</sup> The personnel who slept in air-conditioned buildings, for example, were much more likely to develop a cough and sore throat than those who lived in tents and warehouses.

It is reasonable to expect that inhalation of particulate matter could have resulted in some short-term airway irritation, and could have aggravated personnel with asthmatic conditions that were previously minor or asymptomatic. While little is known specifically regarding the long-term effects of inhaling fine sand, it does not seem likely to be a major contributing factor to the complex of symptoms being reported by veterans.

#### 6. *CARC (Chemical Agent Resistant Coating) Paint*

Chemical agent resistant coating (CARC) used to paint combat vehicles and equipment, releases toluene diisocyanate during the curing process. Some civilian workers and several support units may have conducted painting without required respiratory protection. The extent of such exposures are unlikely to be a factor for the majority of personnel suffering from unexplained symptoms.

### E. **Medical Prophylaxis**

Protective measures taken to prevent chemical or biological warfare casualties included vaccination against anthrax and botulinum toxin and prophylactic use of pyridostigmine as a nerve agent pretreatment. No evidence has been found to implicate any of these measures in the unexplained medical complaints in Gulf War participants.

#### 1. *Pyridostigmine Bromide*

Pyridostigmine Bromide (PB) was issued as a nerve agent pretreatment to nearly all US troops, as well as 45,000 participants from the United Kingdom. Use of low doses (30mg 3x daily) of PB, taken orally upon direction of unit commanders, confers significant protection to troops when used with the other post-attack treatment measures (atropine and 2-Pam chloride). Although all units were given PB, the Department of Defense does not have records of which military personnel actually ingested PB, nor of how many tablets may have been ingested.

Most of the extensive clinical experience with the drug in civilian medicine has been with patients suffering from myasthenia gravis, a neuromuscular disorder. These patients are given doses as high as ten times those taken by troops. Metabolic and toxicologic studies and the relatively small amount of drug actually taken by military personnel make pyridostigmine an extremely unlikely contributing factor in the unexplained medical complaints in Gulf War participants.

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<sup>22</sup>Richards AL, Hyams KC, Watts DM et al. Respiratory disease among military personnel in Saudi Arabia during Operation Desert Shield. *Am J Public Health* 1993; 83:1326-1329.

The Army is preparing a formal NDA (new drug application) submission specifically for the indicated application of CW prophylaxis. The FDA procedures will entail a thorough and formal reexamination of the toxicological, metabolic and epidemiological data. While it is extremely difficult to rule out idiosyncratic side-effects at the level of 1 per thousand or fewer of those exposed, this hypothetical concern should be weighed against the hazards of unprotected exposure to chemical attack.

## 2. *Anthrax Vaccine*

Anthrax vaccine was administered to about 150,000 troops in the theater, about 1/5 of those deployed. The licensed anthrax vaccine, produced by the Michigan State Department of Public Health, has been extensively used for years in civilian wool factory workers and laboratory workers, and its safety is well documented.

## 3. *Botulinus Toxoid Vaccines*

Botulinus toxoid administration was restricted to relatively few units that were thought to be at highest risk. Only about 8000 doses were administered, but hardly any to reservists, which group is prominent among those reporting symptoms. This vaccine is made by the same process as tetanus toxoid that is used in infants worldwide, and is also produced by the Michigan State Department of Public Health.

## F. *Depleted Uranium*

Operation Desert Storm was the first conflict that involved the use of depleted uranium (DU) munitions. Armor piercing projectiles fired from tanks and A-10 aircraft consisted of DU kinetic energy penetrators, enabling U.S. forces to engage and kill enemy vehicles at standoff ranges that enhanced their own safety.

Concern has developed around the possibility that expended DU projectiles, or the dust and fragments from them, posed a residual hazard to troops on the battlefield. Additionally there are a limited number of US soldiers whose vehicle was struck by friendly fire, resulting in DU shrapnel wounds. These soldiers are being followed up by a long-term study that will examine possible chronic effects from embedded DU fragments.

The other highest probability exposures from DU are among a group of maintenance workers who cleaned out a US tank that had been struck by enemy fire and burned while carrying DU ammunition. Careful radiological monitoring of these individuals during and after exposure led to the conclusion that the residual DU particles posed a minimal hazard to personnel working around contaminated vehicles with appropriate protection.



## IX. POST TRAUMATIC STRESS AND SOMATOFORM DISORDERS

### A. Psychiatric Morbidity

Psychiatric morbidity due to service during the Gulf War was predicted to be low for several reasons: the short duration of the conflict, the relatively low casualties sustained by American forces, and the positive support for the war at home. Examination of records of evacuation during the conflict is one approach to examining the extent of psychiatric morbidity: the Army rate of evacuation for psychiatric reasons translated to only 2.7 per 1,000 evacuations per year.<sup>23</sup> This very low rate of psychiatric evacuations is in contrast to prior wars in which evacuations for psychiatric disorders in comparison to total evacuations were: 23% in World War II, 10% for Korea, and 7% from Vietnam<sup>24</sup>. Of the roughly 250 Army personnel evacuated from the Gulf for psychiatric reasons, approximately fifty (20%) were later determined to be disabled for further military service; levels of Post Traumatic Stress Disorder (PTSD) were found to be very low, with only four of these 50 carrying a diagnosis of PTSD<sup>25</sup>. Another approach to assessing psychiatric morbidity possibly relating to service in the Gulf is to examine the numbers of service members referred for disability determination due to psychiatric disorders. As of March 1994, approximately 294 soldiers with psychiatric-related diagnoses were referred for disability determinations. Of these, 112 carried the diagnosis of PTSD.<sup>26</sup> There are several studies in the literature which report on the prevalence of psychiatric disorders and stress symptoms during and following the Gulf

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<sup>23</sup>Hales RE: Psychiatric lessons from the Persian Gulf War. *Hosp Community Psychiatry* 43:769, 1992

<sup>24</sup>Ursano RJ, Holloway HC: *Military Psychiatry*, in *Comprehensive Textbook of Psychiatry/I V*. Edited by Kaplan HI, Sadock BJ. Baltimore, MD, Williams & Wilkins, 1900-1909, 1985

<sup>25</sup>Fagan J., personal communication, 1994

<sup>26</sup>Fagan J., personal communication, 1994

War<sup>27,28,29,30,31,32,33,34</sup>. However, it is difficult to generalize from these papers because of the unique characteristics of the populations studied.

Studies from the Veterans Administration have shown somewhat higher levels of PTSD. A preliminary report estimated a prevalence of PTSD at roughly 9%<sup>35</sup>. Of note is that 34% appeared to have experienced other forms of significant psychological distress upon return<sup>36</sup>.

In the initial phase of the ODS Veterans Survey spanning from October 15, 1991, to April 15, 1992, 1006 surveys were completed; roughly one-half at VA centers, and one-half at outreach locations. A composite PTSD measure was created on the basis of random structured psychiatric telephone interviews and their relation to the completed survey. At the initial survey, PTSD levels were

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<sup>27</sup>Perconte ST, Dietrick AL, Wilson AT, Spiro KJ, Pontius EB: Psychological and war stress symptoms among deployed and non-deployed reservists following the Persian Gulf War. *Milit Med* 158:516-521, 1993

<sup>28</sup>Southwick SM, Morgan A, Nagy LM, Bremner D, Nicolaou AL, Johnson DR, Rosenheck R, Charney DS, et al: Trauma-related symptoms in veterans of Operation Desert Storm: a preliminary report. *Am J Psychiatry* 150:1524-1528, 1993

<sup>29</sup>Labbate LA, Snow MP: Posttraumatic Stress symptoms among soldiers exposed to combat in the Persian Gulf. *Hosp Community Psychiatry* 43(8):831-832, 1992

<sup>30</sup>Perconte S, Wilson A, Pontius E, Dietrick AL, Kirsch C, Sparacino C: Unit-based intervention for Gulf War soldiers surviving a SCUD missile attack: program description and preliminary findings. *Journal of Traumatic Stress* 6(2):225-238, 1993

<sup>31</sup>Johnson LB, Cline DW, Marcum JM, Intress JL: Effectiveness of a stress recovery unit during the Persian Gulf War. *Hosp Community Psychiatry* 43:829-831, 1992

<sup>32</sup>McDuff DR, Johnson JL: Classification and characteristics of Army stress casualties during Operation Desert Storm. *Hosp Community Psychiatry* 43:812-815.

<sup>33</sup>McCarroll JE, Ursano RJ, Fullerton CS: Symptoms of Posttraumatic Stress Disorder following recovery of war dead. *Am J Psychiatry* 150(12):1875-1877, 1993

<sup>34</sup>Garland FN: Combat stress control in the Post-War Theater: mental health consultation during the redeployment phase of Operation Desert Storm. *Milit Med* 158(5):334-338, 1993

<sup>35</sup>Rosenheck R, Becnel H, Blank AS, Farley F, Fontana A, Friedman MJ, Fulton J, Gelsomino J, Grishman M, Gusman F, Keane T, Lehmann L, Podkul TB, Ursano RJ, Wolfe J: Returning Persian Gulf troops: First year findings, VA Northeast Program Evaluation Center (NEPEC), The Evaluation Division of the National Center for PTSD. West Haven, CT, VA Medical Center, 1992

<sup>36</sup>Rosenheck R, Becnel H, Blank AS, Farley F, Fontana A, Friedman MJ, Fulton J, Gelsomino J, Grishman M, Gusman F, Keane T, Lehmann L, Podkul TB, Ursano RJ, Wolfe J: Returning Persian Gulf troops: First year findings, VA Northeast Program Evaluation Center (NEPEC), The Evaluation Division of the National Center for PTSD. West Haven, CT, VA Medical Center, 1992

found to be 36.5% for veterans seeking psychological treatment at Vet Centers ("treatment-seeking"), 4.9% for those veterans seeking other services at Vet centers ("service-seeking"), and 5.3% for veterans who completed the survey at an outreach location ("non-service-seeking")<sup>37</sup>. At the six month follow-up (April 15 -- October 15, 1992), treatment-seeking veterans exhibited less PTSD at follow-up (19.4% compared to 37.1%)<sup>38</sup>. The non-service-seeking veterans exhibited more PTSD (7.6% versus 5.4% at Time 1) and the service-seeking veterans exhibited twice the level of PTSD (9.8% versus 4.9%).<sup>39</sup>

The prevalence of psychiatric conditions in veterans enrolled in the active duty and VA registries for Desert Storm-related conditions appears to be modest. Inpatient primary psychiatric diagnoses in Persian Gulf veterans showed 34.7% suffering from mental disorders; 11.6% from alcohol dependence; 5.1% from drug dependence and 6.1 % from adjustment disorders (including PTSD)<sup>40</sup>. Of the 67 individuals enrolled in the Navy Gulf War registry in February 1994, 6 were listed as having a psychiatric condition as their major complaint (1 adjustment disorder with depressed features; 1 major depression; 4 PTSD)<sup>41</sup>. Approximately 7 other individuals carried associated or incident psychiatric diagnoses (3 depressive disorders, 2 PTSD, 1 adjustment disorder and 2 personality disorders)<sup>42</sup>. Of the 149 individuals enrolled in the Army's Gulf Syndrome Registry as of February 1994, 12 were listed as having presumed or confirmed PTSD; 4 suffered depressive disorders; 2 panic disorders; 1 bipolar disorder.<sup>43</sup> Similarly, a group of 78 veterans complaining of symptoms of fatigue was found to have a low prevalence of psychiatric disorders (@12%).<sup>44</sup>

<sup>37</sup> DoVA Readjustment Counsel Svc(115) Washington DC, 1994, unpublished data

<sup>38</sup> DoVA Readjustment Counsel Svc(115) Washington DC, 1994, unpublished data

<sup>39</sup> National Center for PTSD, preliminary report, 1994

<sup>40</sup> Kang HK, Dalager NA: Health surveillance of Persian Gulf War veterans: a review of the Department of Veterans Affairs Persian Gulf Registry and the Patient Treatment File, 1993

<sup>41</sup> Naval Environmental Health Center, 1994

<sup>42</sup> Naval Environmental Health Center, 1994

<sup>43</sup> Department of the Army, Preventive Medicine Consultants Division, 1994

<sup>44</sup> Defraites RF, Wanat ER, Norwood AE, Williams S, Cowan D, Callahan T: Investigation of a Suspected Outbreak of an Unknown Disease Among Veterans of Operation Desert Shield/Storm. Washington, DC, Walter Reed Army Institute of Research, 1992

## B. Historical Background

Appreciation for the role of situational stress as a major military medical problem began in the latter half of the 19th century and paralleled the development of psychiatry as a medical specialty. During the Civil War, DaCosta attributed a syndrome consisting of generalized weakness to an irritable and exhausted heart. A similar constellation of symptoms was described as neurocirculatory asthenia during World War I.<sup>45</sup> Physicians in the past have attempted to understand the etiology of these syndromes. As in today's discussion of complex illnesses, there was much controversy surrounding the relative contribution of "organic" (medical) versus "functional" (psychological) factors.

In current military psychiatry the term *acute stress reaction* or *battle fatigue* is applied to a wide range of somatic (physical) and psychological responses in the combat theater. When military psychiatric principles of proximity, immediacy and expectancy are employed, the vast majority of these casualties can be returned to duty.

Numerous studies have demonstrated that participating in combat is related to an increase in nonsurgical illness.<sup>46</sup> Much less is known about the longer term medical and psychological consequences of going to war (See Rundell and Ursano<sup>47</sup> for review). Vietnam veterans reported many more physical symptoms and illnesses than did military contemporaries not serving in combat; 25% more Vietnam veterans sought medical care for health problems than did non-combat veterans.<sup>48</sup> Vietnam veterans were almost twice as likely to describe their health as "fair" or "poor" in comparison with veterans during that time period who did not serve in Vietnam (19.6% versus 11.1%).<sup>49</sup> It is of note that physical examinations and laboratory studies found few differences between these two groups.

In looking at the general literature on the relationship of exposure to trauma and subsequent health, numerous investigators have noted a relationship between

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<sup>45</sup>Glass AJ: Army psychiatry before World War II, in *Neuropsychiatry in World War II; Volume I: Zone of Interior*. Edited by Anderson RS, Glass AJ, Bernucci RJ. Office of the Surgeon General, Department of the Army, 1966

<sup>46</sup>Solomon Z: *Body and Soul*, in *Combat Stress Reaction: The Enduring Toll of War*. Edited by Solomon Z. New York, NY, Plenum Press, 1993, pp 147-162

<sup>47</sup>Rundell J, Ursano RJ: *Psychiatric responses to trauma*, in *The Persian Gulf War: Soldiers and Families, Communities and Nations*. Edited by Ursano RJ, Norwood AE, in preparation

<sup>48</sup>Kulka RA, Schlenger WE, Fairbank JA, Hough RL, et al: *National Vietnam veterans readjustment study (NVVRS): Description, current status, and initial PTSD prevalence estimates*. Veterans Administration, Washington, DC, 1988

<sup>49</sup>The Centers for Disease Control Vietnam Experience Study: *Health Status of Vietnam Veterans II. Physical Health*. JAMA 259:2708-2714, 1988

Post-Traumatic Stress Disorder (PTSD) and somatic complaints. For example, 5 out of 9 firefighters with chronic PTSD presented to their physicians with somatic complaints that distracted attention from the underlying PTSD.<sup>50</sup> High amounts of PTSD symptomatology were found to correlate with reports of high amounts of physical health problems in veterans.<sup>51</sup> Similar relationships between PTSD in Vietnam combat-veterans and increased reporting of health complaints were also found by Litz et al<sup>52</sup>. These investigators noted those health complaints in the veterans with PTSD clustered around symptoms suggestive of sympathetic hyperactivity, especially gastrointestinal and cardiopulmonary complaints. Health complaints were found to correlate positively to severity of PTSD. The presence of physician-diagnosed medical conditions did not differentiate between combat veterans with and without PTSD. In a study of Israeli combat veterans<sup>53</sup>, the 50 veterans with PTSD reported significantly more symptoms than did age-matched combat veterans without PTSD. However, the veterans with PTSD did not differ from the controls in findings on physical examination or laboratory evaluation. Solomon and colleagues<sup>54</sup> found that one, two, and three years after their participation in the Lebanon war, Israeli combat veterans who had experienced combat stress reactions during the war reported significantly more health problems.

### C. Relationship Between War-Related Stress and Health

The relationship between exposure to war-related stress and long-term effects on health is not well understood. Various hypotheses have been advanced to explain the ways in which stress can affect health (see Litz et al<sup>55</sup> for a review of

<sup>50</sup>McFarlane AC: The phenomenology of post-traumatic stress disorder following a natural disaster. *J Nerv Ment Dis* 176:22-29, 1988

<sup>51</sup>Stretch RH: Posttraumatic stress disorder among Vietnam and Vietnam era veterans, in *Trauma and Its Wake, Vol 2: Traumatic Stress Theory, Research and Intervention*. Edited by Figley C. New York, NY, Brunner/Mazel, 1986, pp 156-192

<sup>52</sup>Litz BT, Keane TM, Fisher L, Marx B, Monaco V: Physical health complaints in combat-related Post-Traumatic Stress Disorder: a preliminary report. *Journal of Traumatic Stress*, 5:131-141, 1992

<sup>53</sup>Shalev A, Bleich A, Ursano RJ: Posttraumatic Stress Disorder: somatic comorbidity and effort tolerance. *Psychosomatics*, 31:197-202, 1990

<sup>54</sup>Solomon Z: Somatic complaints, stress reaction, and Posttraumatic Stress Disorder: a three-year follow-up study. *Behavioral Medicine*, 14:179-185, 1988

<sup>55</sup>Litz BT, Keane TM, Fisher L, Marx B, Monaco V: Physical health complaints in combat-related Post-Traumatic Stress Disorder: a preliminary report. *Journal of Traumatic Stress*, 5:131-141, 1992

proposed mechanisms). Recent attention has turned to the effects of stress on the endocrine and immune systems<sup>56,57,58</sup>.

In terms of the Persian Gulf War, several studies have found that deployed veterans reported more somatic complaints than did non-deployers. In a study of Desert Storm veterans from New England<sup>59</sup>, in a survey taken 18 months after their return from the Gulf, 32.4% of all respondents reported that their health had changed for the worse since their homecoming. Higher endorsement of symptoms was found in subjects who exceeded clinical cutoffs for PTSD: mean numbers of health problems in this group were nearly triple those of the other soldiers. The 3 most commonly endorsed health problems were general aches and pains, headaches, and a lack of energy.

In a sample of 4334 veterans from Hawaii and Pennsylvania, of whom 1739 deployed to the Persian gulf, both the active duty and reserve sample of deployers were significantly more likely to report higher levels of almost all symptoms, often at rates of two-to-one.<sup>60</sup>

The relationship between self-report of symptoms and diagnoses of PTSD based on questionnaire cut-off scores must be interpreted cautiously, however. In a multiphase study on the physical and psychosocial impact of activation and deactivation on Army Reserve nurses who did not deploy to the Gulf, over half endorsed PTSD symptoms of intrusion in the high range and about two-third endorsed high avoidance symptoms<sup>61</sup>. Given the low casualties sustained during the war and the fact that these nurses were not in the combat theater, it is unlikely that these scores reflect traditional war-related stressors per se. Somatic complaints were endorsed at a high rate by this group with over half complaining of headaches. Sleep disturbance, sore muscles, nausea, and lower back pains were also reported to be common.

The positive correlation between PTSD and health complaints suggests that Desert Storm veterans with PTSD are at higher risk for complaints of health

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<sup>56</sup>Chrousos GP, Gold PW: The concepts of stress and stress system disorders: overview of physical and behavioral homeostasis. *JAMA* 267:1244-1252, 1992

<sup>57</sup>Cohen S, Williamson GM: Stress and infectious disease in humans. *Psychol Bull* 109:5-24, 1991

<sup>58</sup>Malarkey WB, Kiecolt-Glaser JK, Pearl D, Glaser R: Hostile behavior during marital conflict alters pituitary and adrenal hormones. *Psychosom Med* 56:41-51, 1994

<sup>59</sup>Wolfe J, Keane TM, Young BL: From soldier to civilian: acute adjustment patterns of returned Persian Gulf veterans, in *The Persian Gulf War: Soldiers and Families, Communities and Nations*. Edited by Ursano RJ, Norwood AE, in preparation

<sup>60</sup>Marlowe, et al WRAIR, preliminary report on Persian Gulf, 1994

<sup>61</sup>Ryan-Wenger NM: Physical and psychosocial impact of activation and deactivation on Army Reserve nurses. *Milit Med* 157:447-452, 1992

problems. In Vietnam veterans, the National Vietnam Veterans Readjustment Study (NVVRS) found that 15.2% of the male and 8.5% of the female Vietnam theater veterans suffered from PTSD at the time of the survey.<sup>62</sup> In terms of forecasting rates of PTSD from the Gulf War, it may be more instructive to examine the Israeli experience following the 1982 Lebanon War, a war lasting a matter of weeks rather than years. It is important to note that 14% of combat veterans who had not displayed acute stress reactions during combat met diagnostic criteria for PTSD one year after the war.

## X. OTHER SYNDROMES

The medically unexplained illnesses in Gulf War participants have been called a "Mystery Illness," and as such it is instructive to compare and contrast it with other puzzling and controversial illnesses that have been and currently are reported. A unique feature of the Gulf War cases is the relatively short time period and restricted geographic localization of potential causative exposures. This feature of the condition raises suspicion that there was a single (or limited number of) environmental agents responsible for causing the illness.

### A. Multiple Chemical Sensitivities (MCS)

The term "multiple chemical sensitivities" was first used by Cullen in 1987. He defined it as:

"an acquired disorder characterized by recurrent symptoms, referable to multiple organ systems, occurring in response to demonstrable exposure to many chemically unrelated compounds at doses far below those established in the general population to cause harmful effects. No single widely accepted test of physiologic function can be shown to correlate with symptoms."

MCS is the new name given to a condition previously called Environmental Illness (EI), originally proposed by Randolph in the 1950s. Patients with a variety of symptoms but without physiological abnormalities were considered to suffer from a previously undescribed form of sensitivity or allergy to environmental chemicals, foods, and/or drugs, for which restrictive diets and environmental avoidance measures are prescribed.

The list of environmental chemicals purported to cause the condition and trigger symptoms is large and heterogeneous, but items most frequently mentioned by these patients are pesticides, perfumes, organic solvents, vehicle exhaust fumes, fuels, glues, and carpeting.

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<sup>62</sup>Kulka RA, Schlenger WE, Fairbank JA, Hough RL, et al: National Vietnam veterans readjustment study (NVVRS): Description, current status, and initial PTSD prevalence estimates. Veterans Administration, Washington, DC, 1988

Theories of pathogenesis have included immunotoxic, neurotoxic, and psychosomatic mechanisms, but clinical or experimental evidence conclusively validating these theories has yet to appear. A number of independent studies now establish that many patients with the diagnosis of MCS or EI are immunologically normal by objective laboratory test.

Based on a number of published studies of persons diagnosed as MCS, the most frequently reported symptoms, in descending order of frequency, are as follows:

- Fatigue
- Headache
- Nausea
- Confusion
- Memory loss
- Dizziness
- Difficulty concentrating
- Ocular and respiratory irritation
- Musculoskeletal pain
- Visceral pain
- Dyspnea

The concept of MCS and the theories and diagnostic methods of its proponents have continued to be highly controversial for the past 40 years.

#### *Relation to Gulf War Participants with Unexplained Illness*

Discussions of the unexplained medical complaints in Gulf War participants occasionally include reference to MCS. In some cases veterans carry both diagnoses concurrently. In other cases, these complaints are viewed as identical with or as a subset of MCS. The summaries of illness reported among Gulf War participants with unexplained medical complaints examined by the VA show similarities and differences with those reported in MCS. However, the absence of substantial abnormalities on physical examination and laboratory testing is a striking feature of both conditions.

## **B. Chronic Fatigue Syndrome (CFS)**

A committee of the Centers for Disease Control's Division of Viral Diseases in 1988 proposed the name "Chronic Fatigue Syndrome" and established a working case definition<sup>63</sup> to "improve the comparability and reproducibility of clinical research and epidemiological studies, and to provide a rational basis for evaluating

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<sup>63</sup>Holmes G, Kaplan J, Gantz N, et al. Chronic Fatigue Syndrome: A Working Case Definition. *Annals of Internal Medicine*. 1988;108:387-389.



patients who have chronic fatigue of unknown cause." In brief, the diagnosis must fulfill the following 2 major criteria:

1. New onset of debilitating fatigue that does not resolve on bedrest, severe enough to reduce daily activity > 50% for more than 6 months.
2. Other clinical conditions are excluded by appropriate evaluation.

and 6 or more of the following 11 symptom criteria:

1. Mild fever.
2. Sore throat.
3. Painful cervical or axillary lymph nodes.
4. Unexplained generalized muscle weakness.
5. Muscles discomfort or myalgia.
6. Fatigue for 24 hrs after exercise that would have previously been tolerated.
7. Generalized headache of a type not previously experienced.
8. Migratory non-inflammatory arthralgia.
9. Neuropsychologic complaints.
10. Sleep disturbance.
11. Description of the main symptom complex as initially developing over a few hours to a few days.

and 2 or more of the following 3 physical criteria documented by a physician on two or more occasions at least 1 month apart:

1. Temperature 37.6-38.6C (oral) or 37.8-38.3C (rectal)
2. Nonexudative pharyngitis.
3. Palpable or tender cervical or axillary lymph nodes or Eight or more of the symptom criteria.

The name and working case definition of CFS arose from reports beginning in 1985 of clusters and individual case reports of a possible new disease with numerous general and specific symptoms without physical or laboratory abnormalities. The illness was first believed to be a chronic Epstein-Barr virus (EBV) infection because of the presence of EBV antibodies, but further epidemiological investigations revealed that the types and titers of the antibodies in these patients were not clearly distinguishable from those in age-matched healthy controls.

The case definition of CFS was intended as an operational concept designed for research purposes, and the criteria reflect the original concept of the disease as an infectious process. Subsequently, investigators have searched for evidence of infection by other viruses, notably HHV-6 and HTLV-1, to explain the etiology of CFS, but to date a specific causative virus (or group of viruses) has not yet been identified. One theory postulates that CFS can be explained as a chronically "activated" immune system, possibly initiated by a viral infection.

In the past a number of illness "epidemics" have been reported with similar features of subjective symptoms without significant physical abnormalities or identifying diagnostic laboratory tests. Some of these events are:

Los Angeles Co. Hospital Illness (1934)  
 Iceland disease (1948)  
 London Middlesex Hospital disease (1952)  
 Royal Free Hospital Disease (1955)  
 Incline Village (NV) outbreak (1984)

*Relation to Gulf War Participants with Unexplained Illness*

As with MCS, there are similarities and differences between CFS and the unexplained medical complaints in Gulf War participants, but all 3 illnesses are subjective without diagnostic objective criteria by physical examination or laboratory testing.

**C. Symptoms in the General Population**

When considering the rate of occurrence of the reported symptoms in Gulf War veterans, it is instructive to examine what is known about the general occurrence of medical complaints in the population. A number of studies have looked at the prevalence of common symptoms in various outpatient populations. The incidence for some of the symptoms associated with Gulf War veterans is very similar, or even higher, in various groups of subjects studied. For instance, fatigue was reported by between 22 and 51 percent, and headache by 14 to 49 percent.<sup>64</sup>

Additionally of interest, a high percentage of these common complaints cannot be diagnosed with a clear organic etiology, and many of the symptoms do not improve through specific treatment.<sup>65</sup>

One of the clear but challenging goals of researchers in the Gulf War health phenomenon will be to determine what differences exist between the veterans conditions and those that exist at some background in the general population.

**D. Other Coalition Forces**

One striking feature of the post-war health phenomenon is the fact that it has been reported only in US personnel. The Saudi Arabian Ministry of Health, in meetings both with Senator Shelby and with Under Secretary of Defense Dorn, has stated that they have not observed any reports of the typical mix of symptoms being reported by some veterans, nor have they observed in their public health

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<sup>64</sup>Kroenke K et al. Symptoms and Therapy in Medical Outpatients. Arch Intern Med; 150:1688.

<sup>65</sup>Kroenke K, Mangelsdorf AD. Common symptoms in ambulatory care: incidence, evaluation, therapy and outcome. Am J Med 86:262-266, 1989.

surveillance program any unexpected increase in unusual health problems of any sort. They also have specifically stated that there were no reports during the war of any civilians being treated for any injury typical of exposure to chemical warfare agent.

Other European and Middle East region governments who supplied forces to the coalition, during meetings with Senator Shelby, have stated that they have not observed unexplained incidence of disease in their troop populations who served during the war.

The Task Force received presentations by, and enjoyed the participation of, the Director General of the United Kingdom's Chemical & Biological Defense Establishment, Dr. Graham Pearson.

The United Kingdom deployed approximately 45,000 troops to the Persian Gulf War, referred to in their military parlance as Operation Granby. These troops comprised 31,000 ground troops, 5 destroyer/frigates, 5 mine sweepers, 10 support ships, and 75 combat aircraft. The British ground contingent consisted of their 1st Armoured Division, with the 7th and 4th Armoured Brigades, division troops, and several infantry battalions tasked with enemy prisoner of war (EPW) handling. These units were almost exclusively made up of active duty military personnel; only 3.6% were reservists.

For the conduct of the ground war, the British division fell under the operational control of the US VII Corps, and was placed on the inner hinge of the wide sweeping attack around Iraq's western flank.

Although no pattern of illness has been apparent in either the British military medical channels, or in the state-sponsored medical system, with regard to those military veterans who had been deployed into the theater of war, the public there followed with interest the increasingly frequent accounts in the American media regarding the so-called "Gulf War Illness". This interest was heightened following a feature on US reports of a Gulf related illness broadcast during a BBC current affairs program on 7 June 1993. Subsequently, the Minister for the Armed Forces appeared on a later edition of this program, dated 7 July 1993, to urge any Gulf War veterans who were experiencing health problems that they believed may be connected with their Gulf service to contact the Ministry of Defense. As of 17 March 1994, 28 veterans had contacted the Ministry, 14 of who took up the offer of medical assessment by a military consultant. By 17 March 1994, 11 of these had been examined and all have been diagnosed as having standard ailments. Thus, we are not aware of any British soldiers who have undiagnosed medical problems that are similar to those being described for US veterans.

Several similarities exist in potential exposures to the British contingent and the US forces that may ultimately be of use to researchers; in addition to being in the same environmental conditions, the widespread administration of anti-biological warfare vaccines and pyridostigmine bromide (nerve agent pretreatment) within both forces are two of interest.

The British report no incidents of detecting chemical or biological warfare agents, and concur in the assessment that chemical or biological agents were not used during the conflict.

**GLOSSARY**

AC - Hydrogen Cyanide  
AFIP - Armed Forces Institute of Pathology  
ANBACIS - Automated Nuclear Biological and Chemical Information System  
ARCOM - Army Reserve Command  
BUN - Blood Urea Nitrogen  
BW - Biological Warfare  
CAM - Chemical Agent Monitor  
CARC - Chemical Agent Resistant Coating  
CBC - Complete Blood Count  
CBDE - Chemical & Biological Defense Establishment (UK)  
CPK - Creatinine Phospho Kinase  
CBW - Chemical/Biological Warfare  
CENTCOM - (US) Central Command  
CFS - Chronic Fatigue Syndrome  
ChE - Cholinesterase  
CNS - Central Nervous System  
CW - Chemical Warfare  
CX - choking agent (phosgene oxime)  
DEET - diethyl toluamide, insect repellent  
DMDC - Defense Manpower Data Center  
DNBI - Disease/Non-Battle Injuries  
DoD - Department of Defense  
DoVA - Department of Veterans Affairs  
DS/DS - Desert Shield/Desert Storm  
DSB - Defense Science Board  
DU - Depleted Uranium  
EBV - Epstein Barr Virus  
EEG - Electroencephalogram  
EI - Environmental Illness  
EPA - Environmental Protection Agency  
EPW - Enemy Prisoner of War  
Era Veterans - those veterans in service during the same period (as Gulf War veterans) but not actually deployed to the Gulf  
FDA - Food & Drug Administration  
GA - nerve agent (Tabun)  
GB - nerve agent (Sarin)  
GD - nerve agent (Soman)  
GF - flouride-containing organophosphate nerve agent  
HD - blister agent (distilled mustard)

ICD9 - International Classification of Diseases  
ITP - idiopathic thrombocytopenic purpura  
L - blister agent (lewisite)  
LD50 - lethal dose to 50% of exposed population  
MCS - Multiple Chemical Sensitivity  
MRI - Magnetic Resonance Imaging  
NBC - Nuclear, Biological and Chemical  
NDA - New Drug Application  
NRC - National Research Council  
NVVRS - National Vietnam Veterans Readjustment Study  
NYC - New York City  
ODS - Operation Desert Storm (can include Desert Shield)  
PB - Pyridostigmine Bromide  
PTF - Patient Treatment File  
PTSD - Post Traumatic Stress Disorder  
RCP - Referral Center Program  
RDX - Royal Demolition Explosive, an explosive ingredient  
SCUD - Soviet-designed surface-to-surface missile  
UN - United Nations  
UNSCOM - United Nations Special Commission  
US - United States  
USAEHA - US Army Environmental Hygiene Agency  
VAMC - Veterans Affairs Medical Center  
VOC - Volatile Organic Hydrocarbons  
VX - nerve agent  
WW II - World War II

## **APPENDIX A**

## Appendix A

### Summary of Task Force Fact Finding Meetings

#### December 21-22, 1993

- Interagency Efforts
- Current Congressional Concerns
- DoVA Perspective, Clinical Background Information
- Intelligence Assessment of Chemical/Biological Warfare in Gulf War
- Reported Incidents of Chemical Agent Detection or Exposure
- US/Coalition Force Chem/Bio Detection Equipment Capabilities, Limitations & Operational Employment
- Health Effects Overview
- Health Effects of Chemical/Biological Agents
- Iatrogenic Effects (Pyridostigmine Bromide, vaccines)
- 123d ARCOM EPICON Investigation
- Psychosocial Stressors
- 24th Naval Reserve Construction Battalion EPICON Investigation
- Leishmaniasis
- Depleted Uranium
- Kuwaiti Oil Well Fires Studies
- Institute of Medicine's Effort (Charter & law)

#### January 10-11, 1994 (CW/BW Panel)

- Chemical Agent Detection Technology
- Biodetection Program
- Natick Lab Evaluation of T-shirt Color Change
- UK Perspective on Persian Gulf Chemical Incidents
- Low-level Exposure Effects
- Other Detection Programs
- Update on Chemical Incident Review
- Meteorological Assessment of Persian Gulf Region (1/17/91 - 3/2/91)
- Modeling of Czech Incident; Other Hypothetical Scenarios; Cloud Travel; Diffusion Modeling
- OSHA: Effects of Chronic Pesticide Exposure
- EPA: Pesticide Hazards (Low-level Effects)
- VA: Registry Summary
- Joint Service Environmental Support Group

#### January 27-28, 1993 (Medical Panel)

- DoVA Update (Registry, Clinical, Research)
- MG Blanck Update on Middle East Trip
- Medical R&D Presentations
- Multiple Chemical Sensitivities
- Toxicology Forum
  - Organophosphates



- Mustard Agents
- Pyridostogmine Bromide
- Gulf War Tissue Study
- Inhaled Particulates
- Other Health Hazards
- Update on Chemical Incident Review
- Other Gulf War Committees Activities
- Joint Service Environmental Support Group Registry
- Epidemiological Efforts and Plans
- CW/BW Panel Update

February 7-8, 1994 (CW/BW Panel)

- Active Duty Registry Profile
- Chemical Officer Forum
  - UNSCOM Team
  - Central Command
  - Army Central Command
  - Army VII Corps
  - Army 82 Airborne Division
  - Army 2d Chemical Battalion
- Health Panel Update
- UK Presentation
- Modeling Update
  - overhead imagery
  - micrometeorological data
- C/B Detection Program
  - Requirements Development
  - R&D
- Tech Base
- PB Follow-up
- Dead Animals/Sanitation/Insecticides
- VA Update

February 24-25, 1994 (Medical Panel)

- CW/BW Panel Update
- Chronic Fatigue Syndrome
- Proposed Persian Gulf Illness Case Definition
- Gulf War Disease Diagnosis and Treatment (Dr. Hyman)
- Veterans Illness Profile (Mr. Haines)
- Infectious Disease Wrap-up
- VA Epidemiological Review
- Senator Riegle's Study (Mr. Tuite)

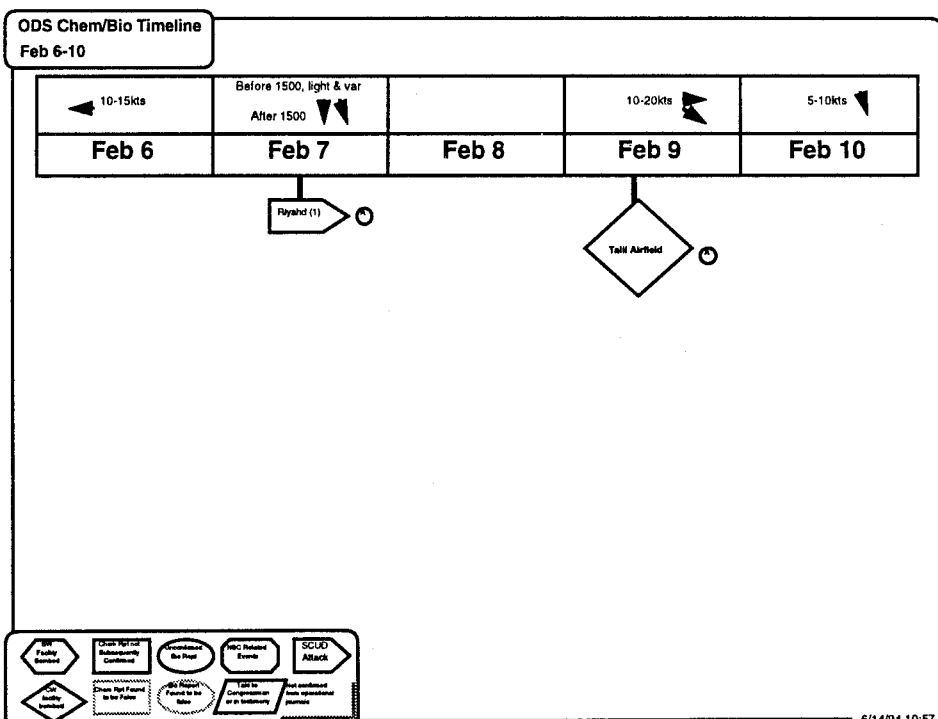
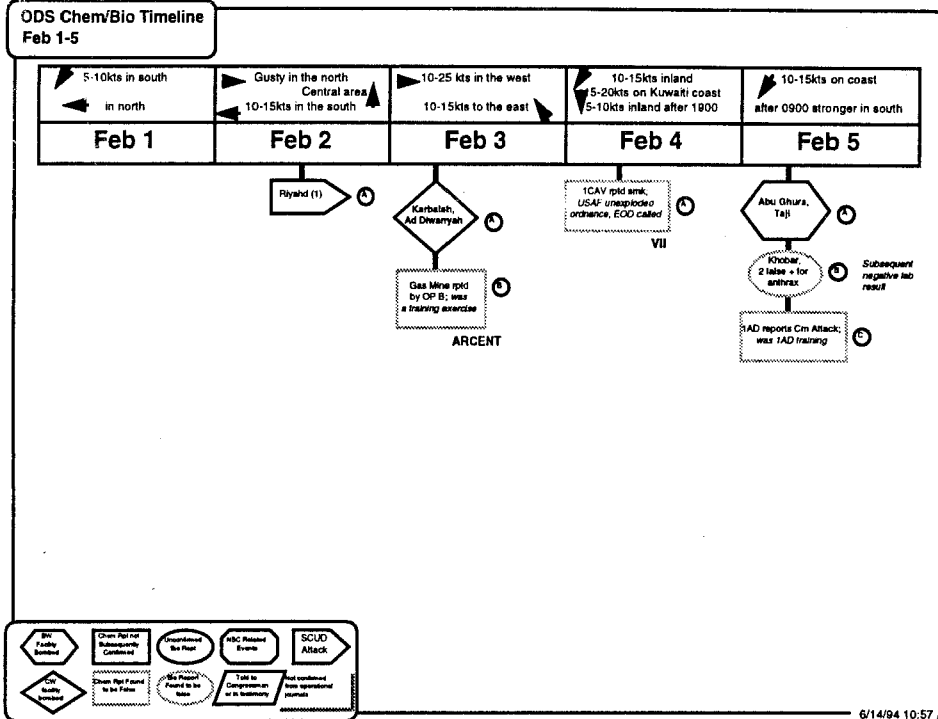
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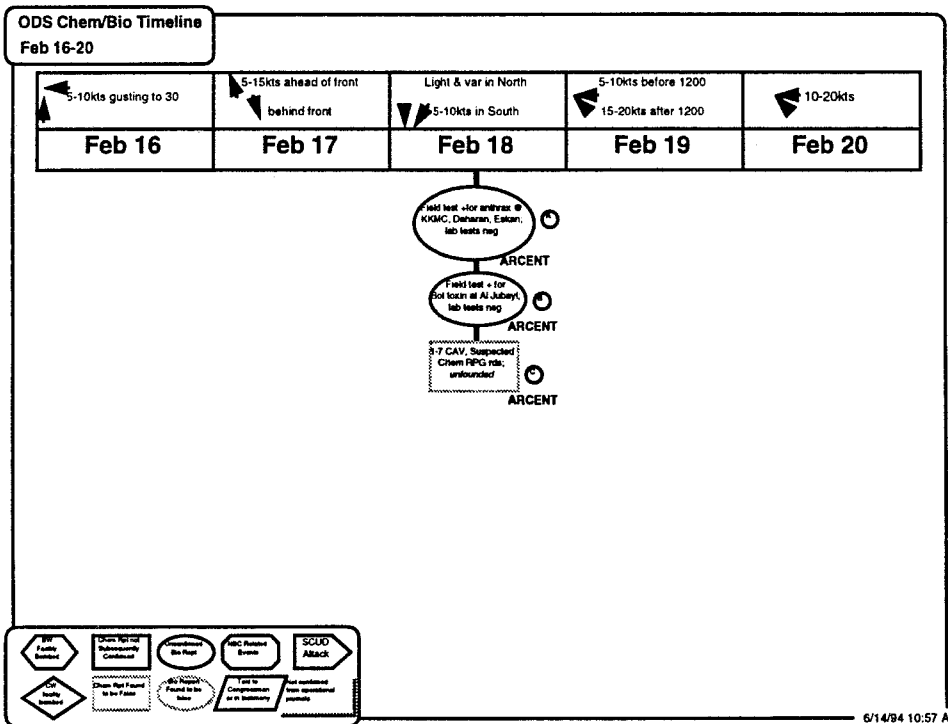
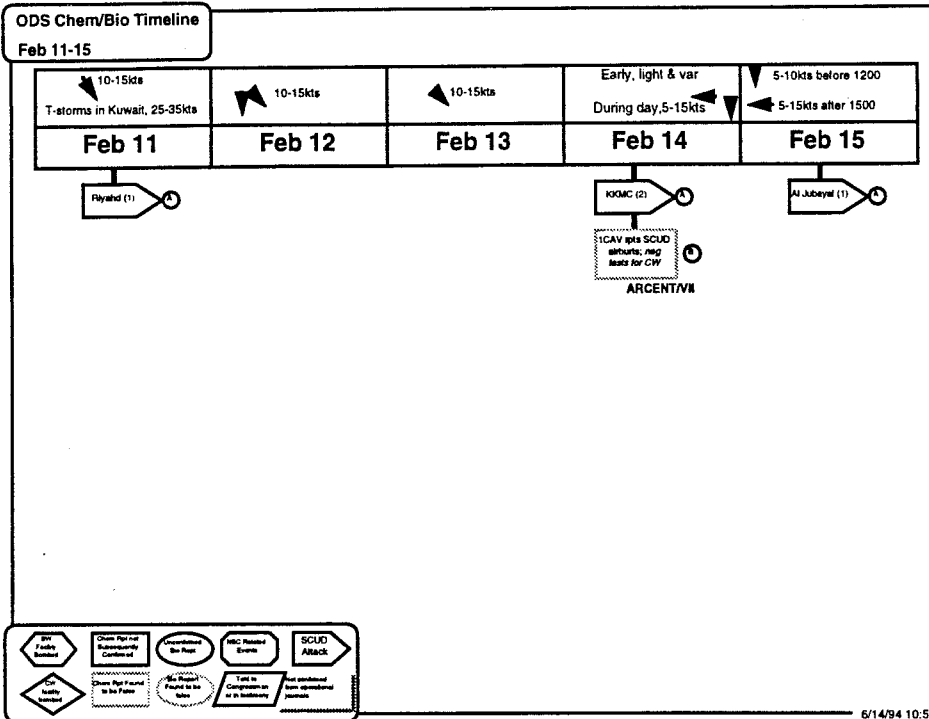
- Normal Incidence of Disease
- Chronic Fatigue Syndrome Case Definition Efforts
- Congressman Browder
- ODS Chem/Bio Event Timeline
- Executive Session

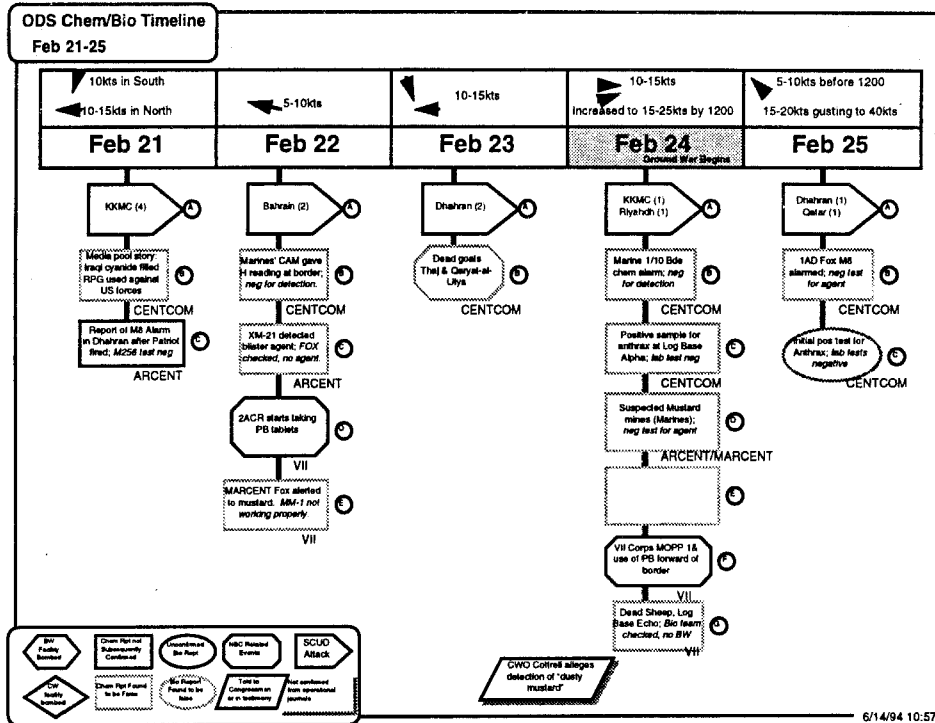
## **APPENDIX B**



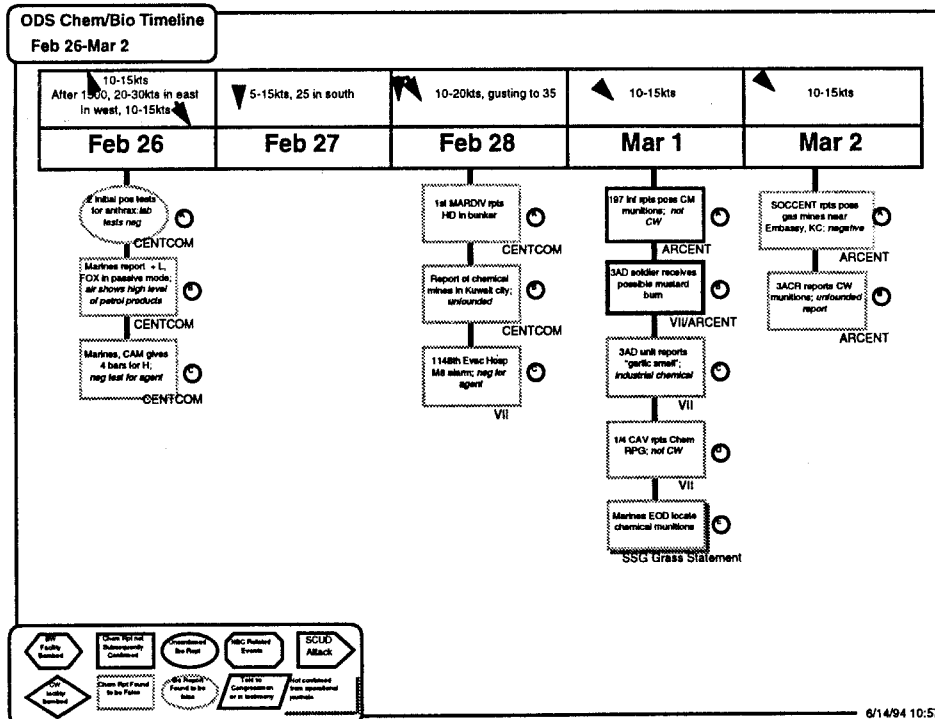








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## **APPENDIX C**

# *Persian Gulf Veterans Coordinating Board*

## *Research*

### DoD Research Activities

#### Review of the Health Consequences of Service During the Persian Gulf War.

Action: National Academy of Sciences (NAS) - Medical Follow-up Agency

Purpose: As directed by P.L. 102-585, the NAS will review existing scientific, medical and other information on the health consequences of military service in the Persian Gulf theater of operations during the Persian Gulf War.

Coordinations: DoD, VA and HHS.

#### Cooperative DoD/VA Research.

Action: DoD and VA Medical Scientists.

Purpose: Support for partial funding of research on the health consequences of exposure to environmental hazards during the Persian Gulf War. Some of this research will take place at VA Medical Centers.

Coordination: DoD, VA and HHS.

#### Leishmania Research.

Action: US Army Medical Research and Development Command.

Purpose: Develop a blood assay for leishmania.

Coordinations: DoD, VA and HHS.

#### Epidemiologic Assessment of Suspected Outbreak of an Unknown Disease Among Veterans of ODS at the Request of the 123d Army Reserve Command, FT. Benjamin Harrison, Indiana.

Action: US Army Medical Research and Development Command.

Purpose: Conducted medical examinations and in-depth surveys of 79 soldiers with symptoms or concerns potentially linked to service in ODS.

Coordinations: DoD, VA and HHS.

#### Stress-Related Survey of Soldiers Deployed in ODS.

Action: US Army Medical Research and Development Command.

Purpose: To identify correlations between post ODS symptoms and occupational and environmental stresses. These questionnaires were completed by active duty and reserve Army, Navy and Air Force personnel in Hawaii and Pennsylvania. Data analysis is in progress.

Coordinations: DoD, VA and HHS.

Retrospective Studies Involving Military Use of Pyridostigmine as a Pretreatment for Nerve Agent Poisoning.

Action: US Army Medical Research and Development Command.

Purpose: Obtain safety data for pending New Drug Application to FDA.

Coordinations: DoD, FDA and VA.

Retrospective Survey of Troops Who Received Clostridium Botulinum Toxoid in the Gulf War.

Action: US Army Medical Research and Development Command.

Purpose: To conduct a retrospective survey of troops who received clostridium botulinum toxoid in the Gulf War after troops returned to the US.

Coordinations: DoD, VA and HHS.

Environmental Toxicology Studies.

Action: Armed Forces Institute of Pathology and Army Environmental Hygiene Agency.

Purpose: To conduct a series of studies in environmental and toxicologic pathology relating to exposures during the Persian Gulf War.

Coordinations: DoD, VA and HHS.

Monitoring Gulf War Veterans With Imbedded Depleted Uranium Fragments.

Action: Armed Forces Radiobiology Research Institute.

Purpose: Conduct clinical follow-up of ODS patients with known or suspected imbedded depleted uranium fragments and assess health risks from imbedded depleted uranium fragments.

Coordinations: DoD, VA and HHS.

Working Group to Establish a Working "Case Definition" for Post-ODS/DS Unexplained Illness.

Action: Walter Reed Army Medical Center.

Purpose: Review and analyze medical records of ODS/DS veterans with unexplained symptoms to establish a working "case definition" for post-ODS/DS unexplained illness.

Coordinations: DoD, VA and HHS.

# *Persian Gulf Veterans Coordinating Board*

## *Research*

### VA Research Activities

#### Children of PG Veterans in Mississippi.

Action: VAMC Jackson.

Purpose: An examination of children born to Persian Gulf veterans for evidence of possible genetically determined health effects related to their parents' service.

Coordinations: VA, DoD and HHS.

#### Review of the Health Consequences of Service During the Persian Gulf War.

Action: National Academy of Sciences (NAS) - Medical Follow-up Agency

Purpose: As directed by P.L. 102-585, the NAS will review existing scientific, medical and other information on the health consequences of military service in the Persian Gulf theater of operations during the Persian Gulf War.

Coordinations: VA, DoD and HHS.

#### Pilot Program to Investigate Medical and Psychological Effects of Exposure to Toxic Hazards.

Action: VAMC Birmingham.

Purpose: Conduct pilot program to investigate medical and psychological effects of exposure to toxic hazards. Results of examinations provided to about 11,000 veterans on VA's PG Registry are also being reviewed to determine if these individuals should be called back for testing.

Coordinations: VA, DoD and HHS.

#### Examining Neuropsychological-Psychological Profiles of Veterans Returning from the Persian Gulf Theater.

Action: VAMC Boston.

Purpose: Conduct a small-scale pilot program examining neuropsychological-psychological profiles of veterans returning from the Persian Gulf Theater.

Coordinations: VA, DoD and HHS.

#### Environmental Hazards Research Centers.

Action: Three VAMCs (to be determined).

Purpose: A request for proposals to establish up to three, VA-based, research centers for the study of the medical consequences of exposure to environmental and toxic hazards, initially focused on the problems cited by personnel in the PG conflict.

Coordinations: VA, DoD and HHS.

Persian Gulf Interagency Research Coordinating Council.

Action: VA, DoD and HHS.

Purpose: VA, DoD and HHS, make up the newly formed Persian Gulf Interagency Research Coordinating Council. The council, established by the Persian Gulf War Veterans' Health Status Act, will coordinate all research activities undertaken or funded by the Executive Branch of the Federal Government on the health consequences of military service in the Persian Gulf theater of operations during the Persian Gulf War. As an initial step, the council members agreed to organize a conference of experts from within and outside the federal agencies, with a goal of reaching a consensus definition of "Persian Gulf Syndrome."

Coordinations: VA, DoD and HHS.

Persian Gulf Advisory Committee.

Action: VA.

Purpose: A 16 member panel composed of experts in environmental and occupational medicine and related fields from both government and the private sector and representatives from veterans service organizations chartered to address issues related to the diagnosis, treatment and research of PG related health conditions.

Coordinations: VA, DoD and HHS.

Investigation of the Relation Between the Experience of ODS and Post-War Adjustment.

Action: VAMC Clarksburg.

Purpose: Assess difficulties in post-war adjustment among ODS soldiers.

Coordinations: VA, DoD and HHS.

Early Intervention with Appalachian Marine Reservists in ODS.

Action: VAMC Mountain Home, TN.

Purpose: To provide an early intervention debriefing to Marine reservists about the stresses of deployment and combat. Follow-up contacts and tests indicated a high degree of PTSD.

Coordinations: VA, DoD and HHS.

Desert Storm Reunion Survey.

Action: VAMC Boston.

Purpose: Study a broad range of combat and non-combat experiences associated with deployment during ODS. The study will delineate and quantify those experiences and determine their impact on subsequent patterns of adjustment.

Coordinations: VA, DoD and HHS.

Psychological Assessment of Operation Desert Storm Returnees.

Action: VAMC New Orleans.

Purpose: Conduct comprehensive psychological assessments and debriefings of troops mobilized in ODS.

Coordinations: VA, DoD and HHS.

Operation Desert Storm Follow-Up Survey.

Action: VAMC Salt Lake City.

Purpose: A survey designed to elicit VA medical center employees perceptions of ODS activation, deployment, and reintegration experiences.

Coordinations: VA, DoD and HHS.

Psychological Adjustment in ODS Veterans.

Action: VAMC Gainesville.

Purpose: A study of 542 National Guard and Reserve members was conducted with one group being actively involved in ODS and a Control group. Psychological tests were given to determine if differences existed between the service veterans and the control group in terms of overall mental health.

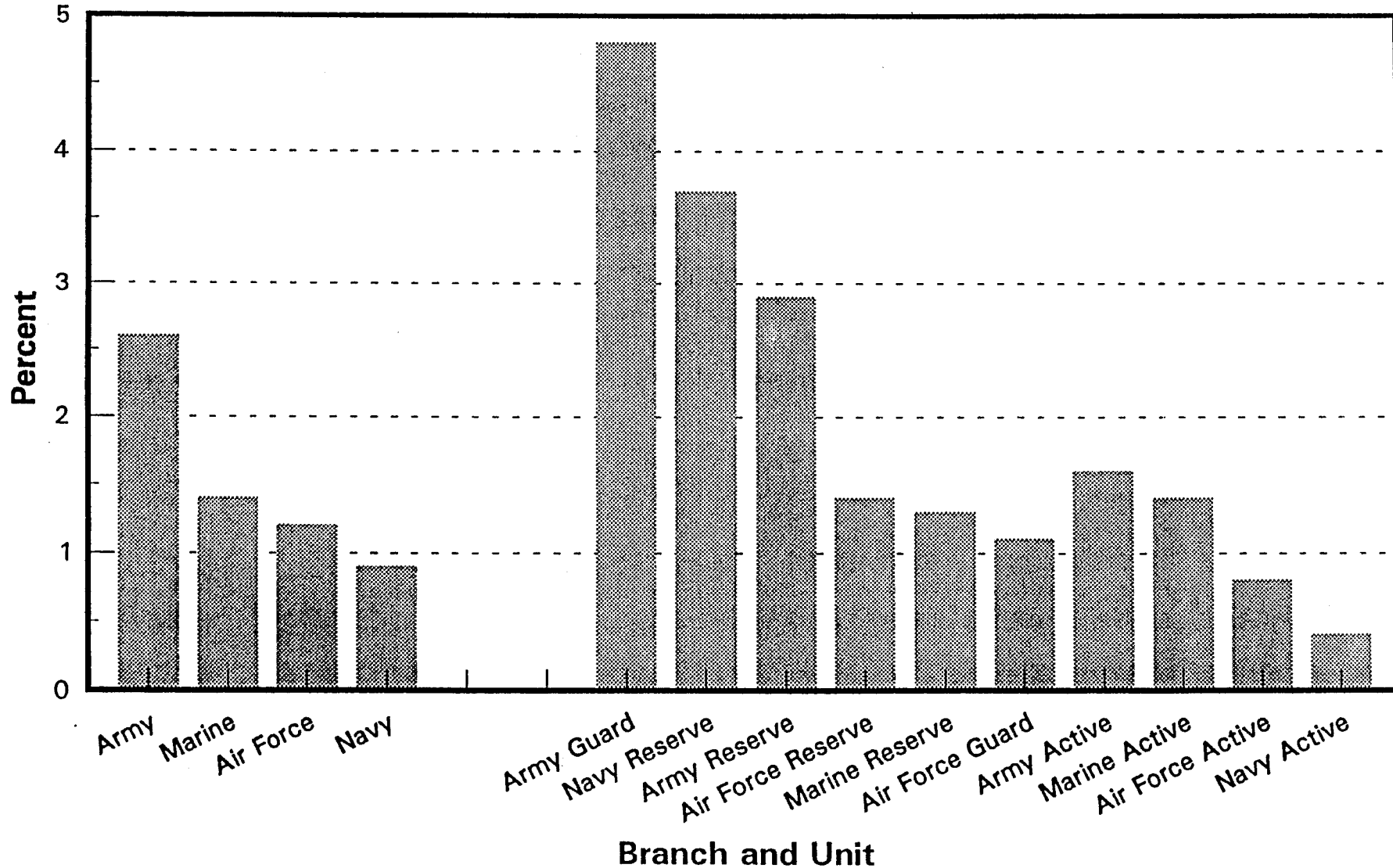
Coordinations: VA, DOD and HHS

## **APPENDIX D**

# Figure 1

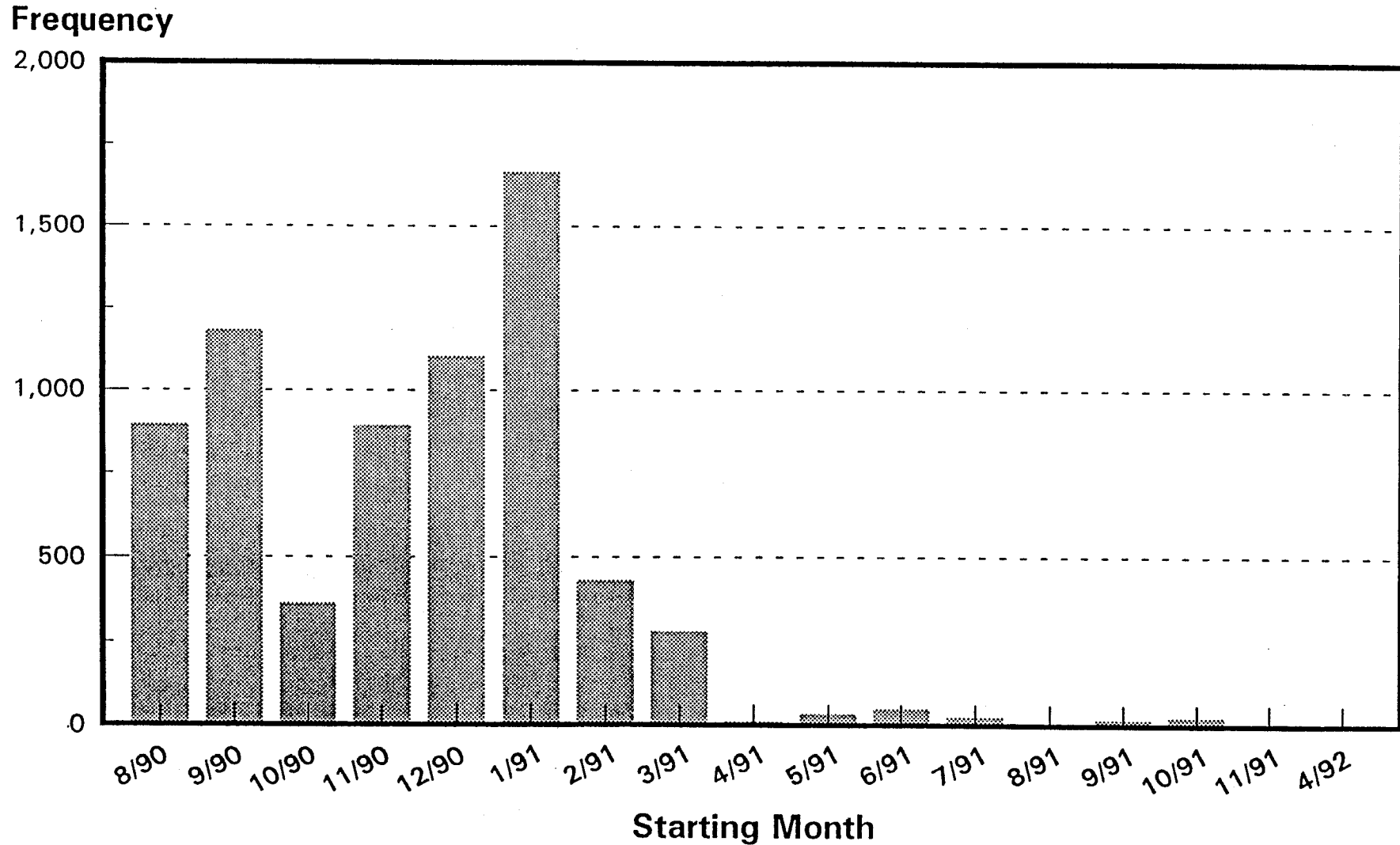
## Persian Gulf Registry Participation Rate

Excluding Those Who Were Still on Active Duty as of September 30, 1993--by Branch and Unit Status

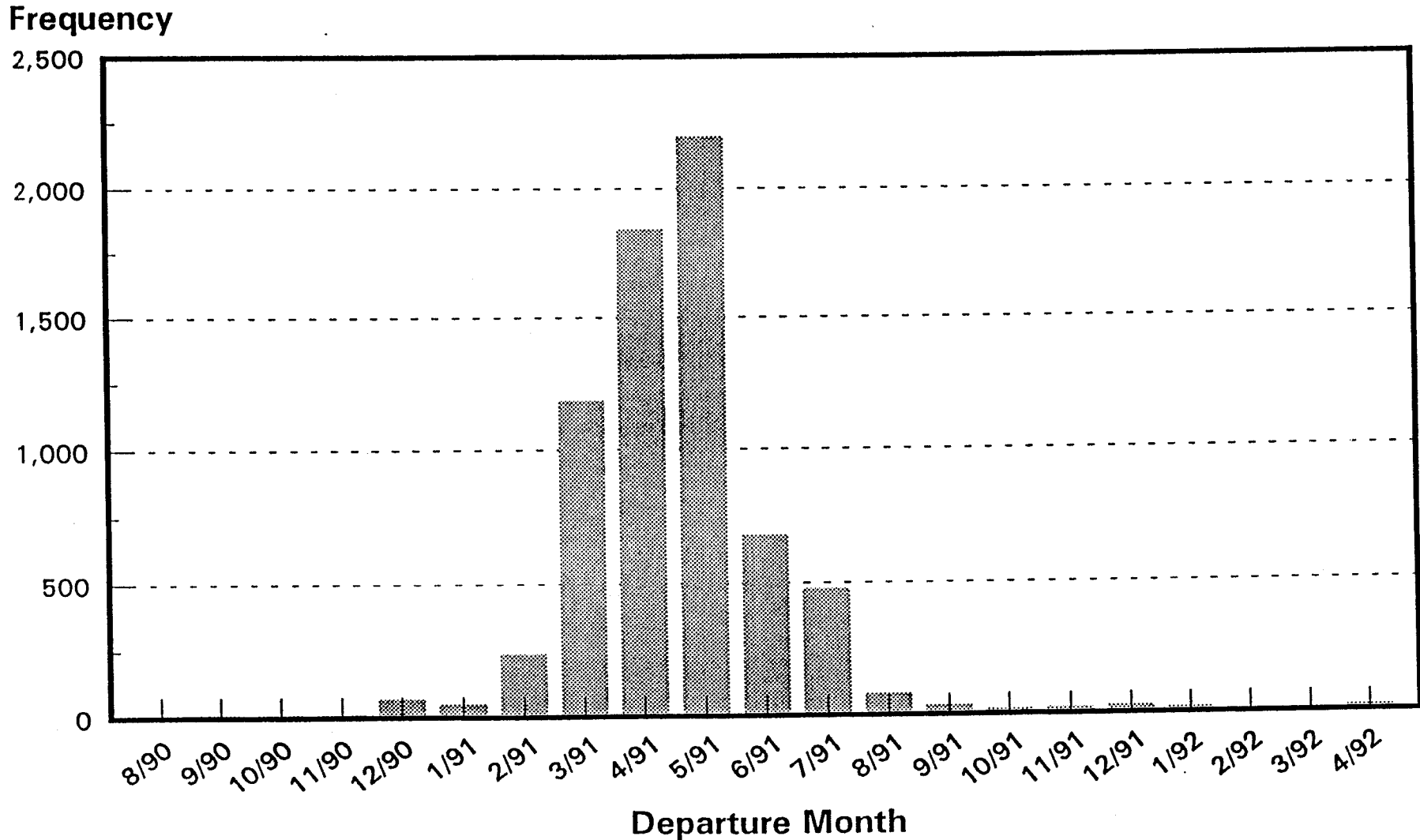




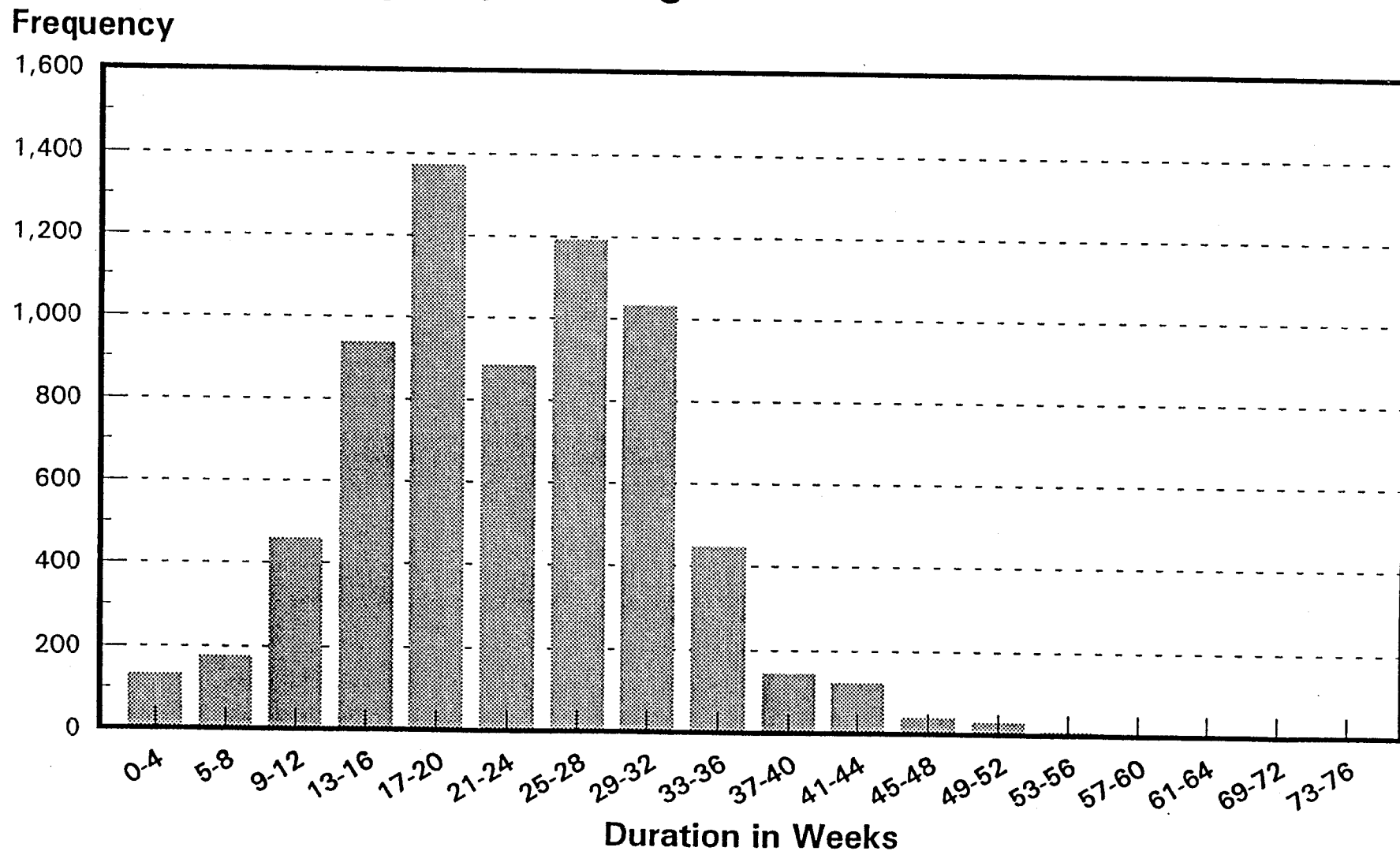
**Figure 2**  
**Distribution of Month of Arrival in the Persian Gulf Area for 6,979 Veterans in the Registry Through November 1993**



**Figure 3**  
**Distribution of Month of Departure from the Persian Gulf Area for 6,979 Veterans in the Registry Through November 1993**



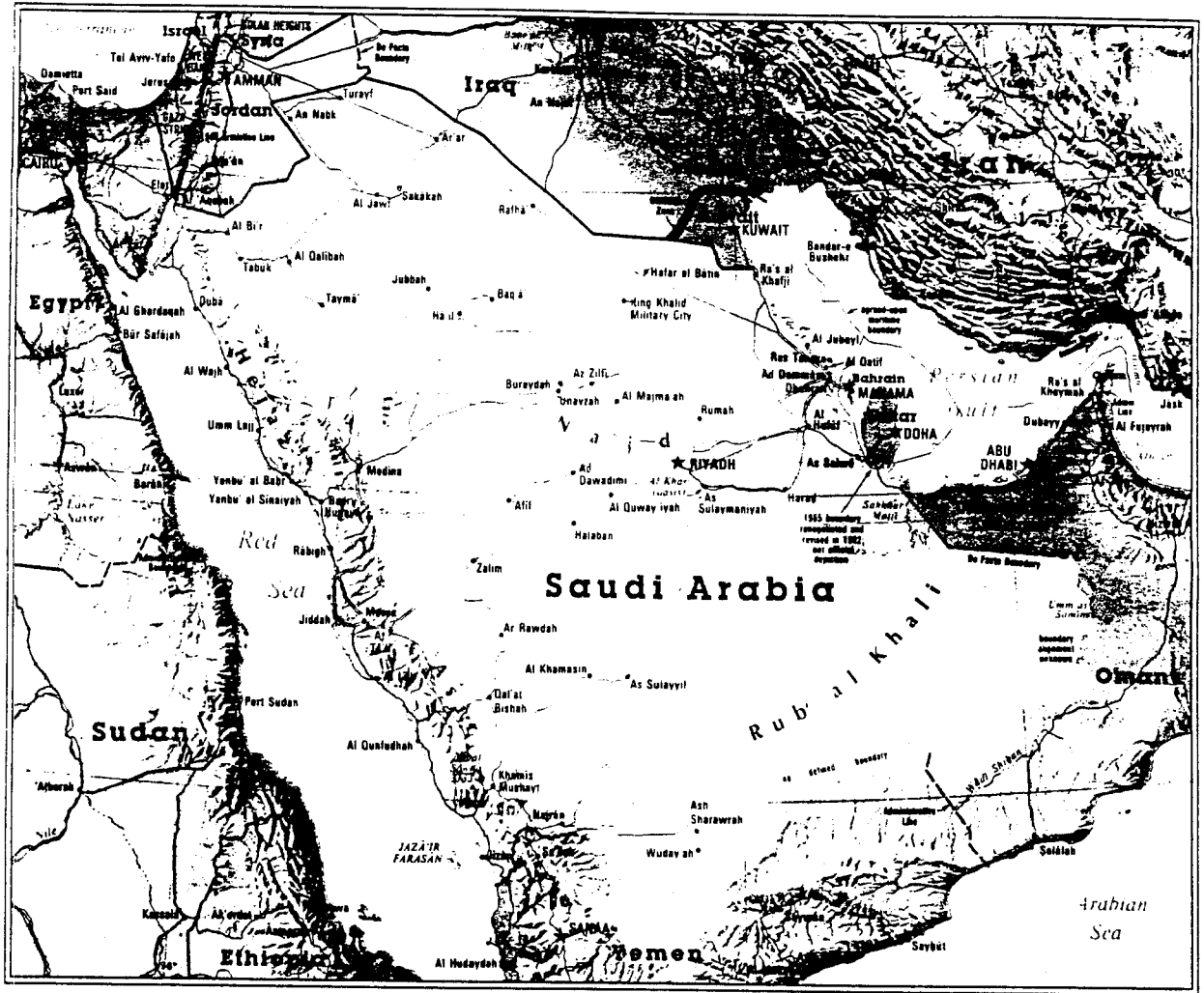
**Figure 4**  
**Distribution of Duration of Stay in the**  
**Persian Gulf Area for 6,979 Veterans in the**  
**Registry Through November 1993**



## **APPENDIX E**



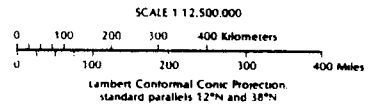
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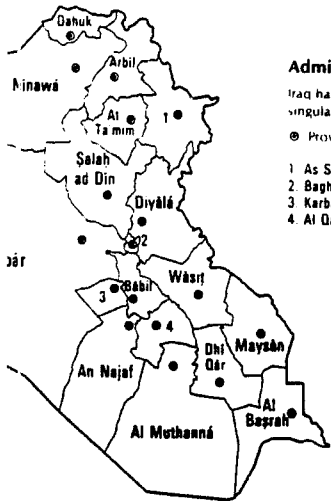
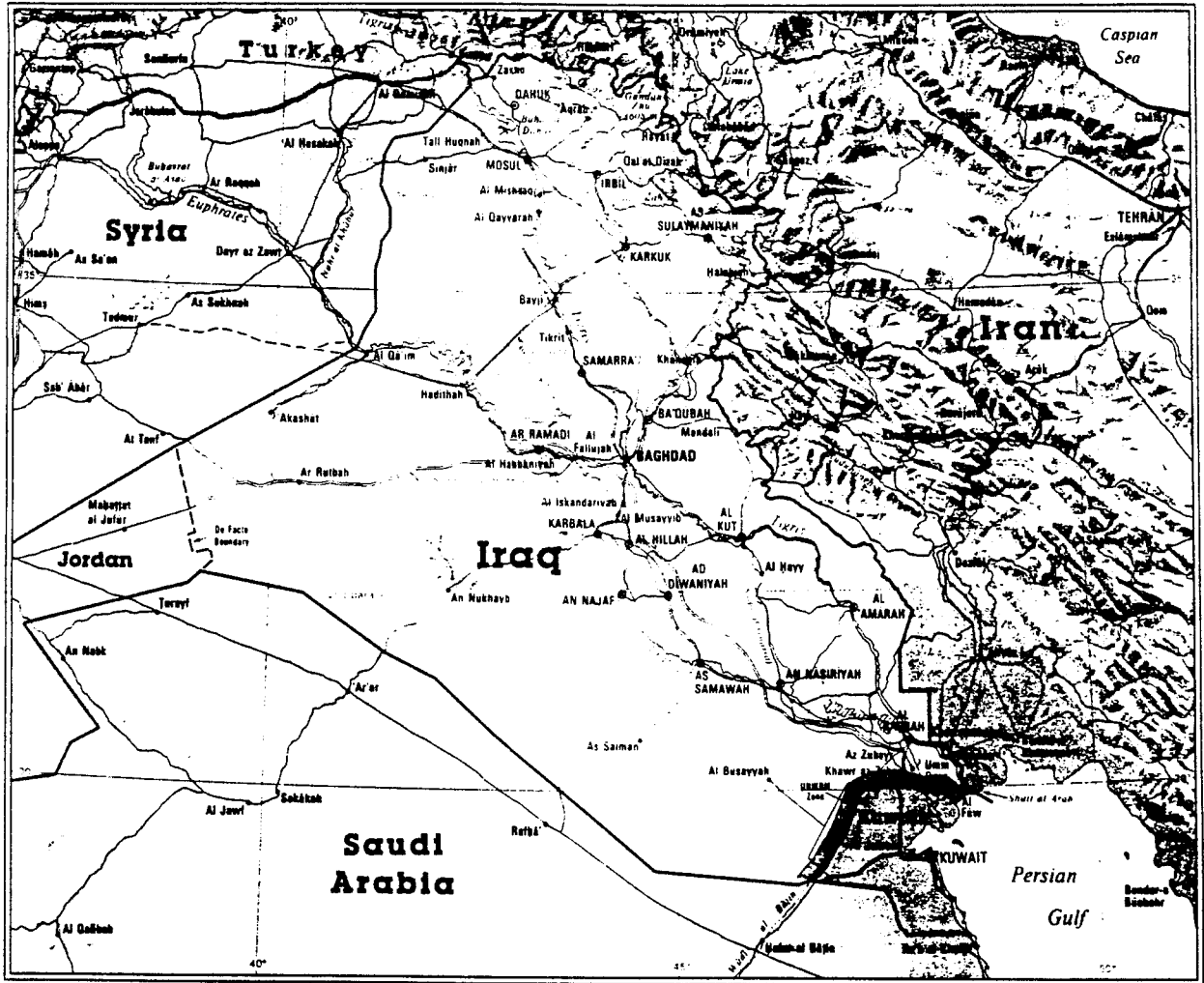
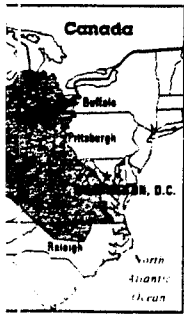


**Administrative Divisions**

Saudi Arabia has 14 emirates (imarat, singular imarah). All are administered from Riyadh.

- International boundary
- ★ National capital
- Railroad
- Expressway
- Road





**Administrative Divisions**

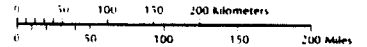
Iraq has 18 provinces (*muhāfazat*, singular *muhāfazah*).

● Province capital

1. As Sulaymāniyah
2. Baghdād
3. Karbalā
4. Al Qādisiyyah

- International boundary
- ★ National capital
- Province capital
- Railroad
- Expressway
- Road
- - - Track

SCALE 1:6 430 000



Lambert Conformal Conic Projection, standard parallels 12°N and 38°N