Y4
.G74/7
En8
KANSAS STATE UNIVERSITY LIBRARIES
1016
GOVERNMENT
Storage

ENVIRONMENTAL DANGERS OF OPEN-AIR TESTING OF LETHAL CHEMICALS

HEARINGS

BEFORE A

SUBCOMMITTEE OF THE COMMITTEE ON GOVERNMENT OPERATIONS HOUSE OF REPRESENTATIVES

NINETY-FIRST CONGRESS

FIRST SESSION

MAY 20 AND 21, 1969

Printed for the use of the Committee on Government Operations

KSU LIBRARIES
A11900 788444

U.S. GOVERNMENT PRINTING OFFICE
31-509 WASHINGTON : 1969

AUTHENTICATED
U.S. GOVERNMENT
INFORMATION
GPO

COMMITTEE ON GOVERNMENT OPERATIONS

WILLIAM L. DAWSON, Illinois, *Chairman*

CHET HOLIFIELD, California
JACK BROOKS, Texas
L. H. FOUNTAIN, North Carolina
JOHN A. BLATNIK, Minnesota
ROBERT E. JONES, Alabama
EDWARD A. GARMATZ, Maryland
JOHN E. MOSS, California
DANTE B. FASCELL, Florida
HENRY S. REUSS, Wisconsin
JOHN S. MONAGAN, Connecticut
TORBERT H. MACDONALD, Massachusetts
WILLIAM S. MOORHEAD, Pennsylvania
CORNELIUS E. GALLAGHER, New Jersey
WILLIAM J. RANDALL, Missouri
BENJAMIN S. ROSENTHAL, New York
JIM WRIGHT, Texas
FERNAND J. ST GERMAIN, Rhode Island
JOHN C. CULVER, Iowa
FLOYD V. HICKS, Washington

FLORENCE P. DWYER, New Jersey
OGDEN R. REID, New York
FRANK HORTON, New York
DONALD RUMSFELD, Illinois
JOHN N. ERLENBORN, Illinois
JOHN W. WYDLER, New York
CLARENCE J. BROWN, Ohio
GUY VANDER JAGT, Michigan
JOHN T. MYERS, Indiana
WILLIAM O. COWGER, Kentucky
GILBERT GUDE, Maryland
PAUL N. McCLOSKEY, JR., California
PAUL FINDLEY, Illinois
JOHN H. BUCHANAN, JR., Alabama
LOWELL P. WEICKER, JR., Connecticut

CHRISTINE RAY DAVIS, *Staff Director*
JAMES A. LANIGAN, *General Counsel*
MILES Q. ROMNEY, *Associate General Counsel*
J. P. CARLSON, *Minority Counsel*
WILLIAM H. COPENHAVER, *Minority Professional Staff*

CONSERVATION AND NATURAL RESOURCES SUBCOMMITTEE

HENRY S. REUSS, Wisconsin, *Chairman*

JIM WRIGHT, Texas
FLOYD V. HICKS, Washington
JOHN E. MOSS, California

GUY VANDER JAGT, Michigan
GILBERT GUDE, Maryland
PAUL N. McCLOSKEY, JR., California

PHINEAS INDRITZ, *Chief Counsel*
EDNA GASS, *Professional Staff Member*
LAURENCE DAVIS, *Assistant Counsel*
JOSEPHINE SCHEIBER, *Research Analyst*
GERALD S. SCHATZ, *Professional Staff Member*
CATHERINE L. HARTKE, *Clerk*

CONTENTS

Hearings held on— Page

May 20 ... 1

May 21 ... 109

Statement of—

Davis, Dr. Gustave L., assistant pathologist, Jewish Hospital of St. Louis; instructor in pathology, School of Medicine, Washington University, St. Louis; chairman, Chemical and Biological Warfare Subcommittee, Committee for Environmental Information, Washington University, St. Louis; on behalf of the Committee for Environmental Information ... 36

Emerson, Dr. K. C., Acting Deputy Assistant Secretary of the Army (Research and Development), accompanied by Dr. Mortimer A. Rothenberg, Scientific Director, Deseret Test Center; and Brig. Gen. William W. Stone, Director of Materiel Requirements, Army Materiel Command ... 113

Gordon, Dr. Clarence C., plant pathologist; professor of botany, University of Montana, Missoula, Mont.; member, Board of Experts, Rachel Carson Trust for the Living Environment ... 106

Keith, James O., Research Biologist, U.S. Department of the Interior Bureau of Sport Fisheries and Wildlife, Davis, Calif ... 99

Lloyd, Hon. Sherman P., a Representative in Congress from the State of Utah ... 23

McCarthy, Hon. Richard D., a Representative in Congress from the State of New York ... 2

Moulton, Dr. Barbara, on behalf of the National Board, American Veterans Committee, Inc ... 178

Osguthorpe, Dr. D. A. (D.V.M.), veterinarian, consultant to Utah State Department of Agriculture, Salt Lake City, Utah; special representative of Governor of Utah in investigation of March 1968 sheep deaths ... 63, 144

Reuss, Hon. Henry S., a Representative in Congress from the State of Wisconsin, and chairman, Conservation and Natural Resources Subcommittee ... 1

Sidel, Dr. Victor W., chief, Community Medicine Unit, Massachusetts General Hospital; assistant professor of medicine, Harvard University Medical School ... 53

Stewart, Dr. William H., Surgeon General, U.S. Public Health Service, Department of Health, Education, and Welfare ... 157

Van Kampen, Dr. Kent R., veterinary pathologist, Agricultural Research Service, U.S. Department of Agriculture, Logan, Utah ... 66

Williams, Philip, Jr., Assistant Chief, Scientific Services Division, Weather Bureau, ESSA, Department of Commerce, Salt Lake City, Utah ... 61

Letters, statements, etc., submitted for the record by—

Davis, Dr. Gustave L., assistant pathologist, Jewish Hospital of St. Louis; instructor in pathology, School of Medicine, Washington University, St. Louis; chairman, Chemical and Biological Warefare Subcommittee, Committee for Environmental Information, Washington University, St. Louis; on behalf of the Committee for Environmental Information: Statement ... 36

Emerson, Dr. K. C., Acting Deputy Assistant Secretary of the Army (Research and Development):

Department of Defense budget for chemical and biological activities, fiscal years 1967–69, table ... 128

Statement ... 110

Letters, statements, etc.—Continued

Page

Gordon, Dr. Clarence C., plant pathologist; professor of botany, University of Montana Missoula, Mont.; member, Board of Experts, Rachel Carson Trust for the Living Environment: Statement 104

Lloyd, Hon. Sherman P., a Representative in Congress from the State of Utah:

Additional information from the Department of the Army dated May 26, 1969, re military payroll—State of Utah for fiscal year 1967 34

Department of the Army statement of May 20, 1969, re biologically contaminated area at the Army's Dugway Proving Ground, Utah 26

Department of Defense, fiscal year 1969, estimated pay for State of Utah, table 35

Department of Defense prime contract awards of $10,000 or more in Utah, July 1968 to March 1969, table 35

Letter to Hon. Henry S. Reuss, chairman, Conservation and Natural Resources Subcommittee, dated May 21, 1969, re supplementary remarks concerning statement made before the subcommittee on May 20, 1969 25

McCarthy, Hon. Richard D., a Representative in Congress from the State of New York: Correspondence between himself and the Department of Defense re programs and policies in the fields of chemical and biological warfare dated March 7, 1969, and April 15, 1969, respectively 11

Moulton, Dr. Barbara, on behalf of the National Board, American Veterans Committee, Inc.: Statement 173

Reuss, Hon. Henry S., a Representative in Congress from the State of Wisconsin, and chairman, Conservation and Natural Resources Subcommittee:

Department of the Army report on the amount of compensation for the loss of the sheep 151

Department of Defense prime contract awards of $10,000 or more with E. I. du Pont de Nemours & Co. and the Remington Arms Co., fiscal year 1968 119

Department of Defense prime contract awards of $10,000 or more with E. I. du Pont de Nemours & Co. and the Remington Arms Co., July 1968 to March 1969 119

Letter from S. Dillon Ripley, Secretary, Smithsonian Institution dated June 5, 1969, re their Pacific oceanic bird project 56

Letter of June 9, 1969, from subcommittee members to Army Secretary Stanley R. Resor requesting declassification of open-air testing data; subcommittee press release, and declassified material 148

Supplementary statements of Dr. Victor W. Sidel, and Dr. William H. Stewart 166, 168

Stewart, Dr. William H., Surgeon General, U.S. Public Health Service, Department of Health, Education, and Welfare: Utah community pesticide study response to the Skull Valley sheep incident, presented at the annual project director's meeting—Atlanta, Ga 170

Van Kampen, Dr. Kent R., veterinary pathologist, Agricultural Research Service, U.S. Department of Agriculture, Logan, Utah:

Agricultural Research Service report on sheep losses in Utah during March 1968 74

Article from the Journal of the American Veterinary Medical Association dated March 15, 1969, entitled "Organic Phosphate Poisoning of Sheep in Skull Valley, Utah" 68

Williams, Philip, Jr., Assistant Chief, Scientific Services Division, Weather Bureau, western region, ESSA, Department of Commerce: Statement 58

APPENDIXES

Page

Appendix 1.—Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground, Department of the Army, Washington, D.C., November 1968 187

Appendix 2.—"The Wind From Dugway," by Virginia Brodine, Peter P. Gaspar, and Albert J. Pallmann (from Environment magazine, vol. II, January–February 1969) 209

Appendix 3.—Statement of Brig. Gen. William W. Stone, Office Director, Research and Laboratories, U.S. Army Materiel Command, Washington, D.C., March 25, 1968; and press releases from office of Senator Frank E. Moss of Utah, concerning the March 13, sheep kill 220

Appendix 4.—Department of Defense, Office of Public Affairs, Washington, D.C., April 18, 1968, "Status Report on Investigation of Sheep Deaths in Utah" 227

Appendix 5.—"Chemical Weapons—What They Are, What They Do," by Victor W. Sidel and Robert M. Goldwyn (from "Scientist and Citizen," special chemical and biological warfare issue, August–September 1967) 229

Appendix 6.—Reports by Dr. C. C. Gordon, associate professor of botany, University of Montana, Missoula, Mont. (A—"East Helena Reports on Air Pollution Abatement"; B—Cominco American Report.") 238

Appendix 7.—"Investigation of Sheep Deaths—Skull Valley, Utah," Department of Health, Education, and Welfare, Health Services and Mental Health Administration, DP National Communicable Disease Center—Atlanta, Ga., April 29, 1968 246

Appendix 8.—Memorandum to Hon. Henry S. Reuss from Freeman H. Quimby, Specialist, Life Sciences, Legislative Reference Service, Library of Congress, Washington, D.C., on the subject of "The Hydrolysis of the Organophosphates as Related to the Toxicity of the Degradation Products of VX"—June 16, 1969 254

MAPS

1. U.S. Air Force Vicinity Map of Wendover Air Force Base (July 1967, Tab NR, R–1) 19

2. Detail from U.S. Air Force Vicinity Map of Wendover Air Force Range (July 1967, Tab NR, R–1), showing "Permanent Bio Contaminated Area" 20

3. Department of the Army "Dugway Proving Ground Reservation Map," Drawing No. F/000/10 22

4. Partial map of Utah showing Skull Valley in relation to Salt Lake City 69

5. Map of Skull Valley, Utah, showing location of affected bands of sheep in relation to Dugway Proving Ground 70

6. Map of Wendover Bombing and Gunnery Range, including Dugway Proving Ground and Tooele 207

7. Map of Dugway Proving Ground and environs, showing location of affected and unaffected sheep flocks 224

ENVIRONMENTAL DANGERS OF OPEN-AIR TESTING OF LETHAL CHEMICALS

TUESDAY, MAY 20, 1969

HOUSE OF REPRESENTATIVES,
CONSERVATION AND NATURAL
RESOURCES SUBCOMMITTEE,
OF THE COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C.

The subcommittee met at 10 a.m. in room 2203, Rayburn House Office Building, Hon. Henry S. Reuss (chairman of the subcommittee) presiding.

Members present: Representatives Henry S. Reuss, Floyd V. Hicks, Guy Vander Jagt, and Gilbert Gude.

Staff members present: Phineas Indritz, subcommittee chief counsel; Mrs. Edna Gass and Gerald S. Schatz, subcommittee professional staff members; and James A. Lanigan, general counsel, and J. P. Carlson, minority counsel, Committee on Government Operations.

Mr. REUSS. Good morning. The Conservation and Natural Resources Subcommittee will be in order.

We open hearings today on whether open-air testing by the Army of persistent lethal agents is endangering the environment. These lethal chemicals and biological agents are tested at the Dugway Proving Ground, of the U.S. Army Materiel Command, located on the eastern edge of the Great Salt Lake Desert in the State of Utah.

The area west of Dugway Proving Ground is largely uninhabited and consists of barren salt flats. But to the north and east of the proving ground are Utah's principal cities, forests, vacation sites, grazing lands, and one of the Nation's major series of wildlife refuges and wildlife management areas. Prevailing winds blow from west to east.

Directly to the north and east of the proving ground are Skull Valley and Rush Valley, inhabited by ranchers and the residents of a few small communities. In these valleys are public lands administered by the Bureau of Land Management as well as private lands, on which horses and cattle graze throughout the year, and sheep graze from November to May. A network of local roads in the valleys is, of course, traveled by visitors and residents alike. Paralleling the northern boundary of the proving ground are the Western Pacific Railroad and U.S. 40, a major transcontinental highway leading west from Salt Lake City.

Within a 100-mile arc radiating from the northeastern edge of the proving ground are the major cities of Salt Lake, Logan, Brigham City, Ogden, and Provo, as well as numerous smaller cities and towns. In this area live 95 percent of the human population of Utah.

The area is crisscrossed with historic trails, which tourists are encouraged to travel. The Pony Express route skirts the southern boundary of the proving ground. The great Wasatch National Forest starts just east of Salt Lake City and merges with the Uinta National Forest to the south. These forests, and the fresh waters of Utah Lake and its tributaries, attract tens of thousands of campers, hunters, sport fishermen, skiers, and other visitors each year. Marshlands east of the Great Salt Lake, beginning at the Bear River Migratory Bird Refuge and going southward to the mouth of the Jordan River, include numerous wildlife areas. The Fish Springs National Wildlife Refuge, outside of this chain, is located directly on the southern border of the proving ground. These rich wildlife habitats are located on the Central and Pacific Flyways, and seasonally abound in migratory birds as well as indigenous species.

These, then, are some of the people and natural resources immediately endangered if poisonous chemicals or deadly viruses should escape the boundaries of the proving ground. In March of last year, an airplane spray test at Dugway of the nerve gas, VX, appears to have caused the death of more than 6,000 sheep. The sheep were grazing in the adjoining Skull and Rush Valleys, in locations up to some 45 miles from the test site.

The sheep disaster demonstrated that the air above Dugway Proving Ground can't be counted on as a contained test chamber. The air moved and carried with it some part of the toxic cloud of VX. Had the wind been stronger, the cloud could have moved even farther and possibly brought death or injury to a much wider arc. The question, therefore, is whether it is possible both to release lethal chemicals, germs, or viruses into the air and to assure the safety of people, domestic animals, and wildlife using the air.

Our first witness is Congressman Richard D. McCarthy of New York.

Congressman McCarthy, do you have a prepared statement?

STATEMENT OF HON. RICHARD D. McCARTHY, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF NEW YORK

Mr. McCarthy. Yes, I do, and with your permission I would like to quickly read it, to do it all in about 15 minutes.

Thank you, Mr. Chairman.

I welcome the opportunity to testify before your subcommitte on the hazards connected with the atmospheric testing of chemical and biological warfare agents. One of my questions to Secretary Laird in my March 7, 1969, letter was:

> What precautions are taken to insure that chemical and biological warfare experiments are of no danger to the public? What precautions did not work at the sheep-kill at Skull Valley in Utah?

The question of public health and welfare in relation to these activities is fundamental. There is no room for mistakes, for official investigations after a tragedy. The American public is entitled to the assurances that there will be no compromises with public safety or health in connection with or chemical and biological warfare activities.

I am concerned about the nature of the assurances received because in that same letter I asked about the safety measures taken in the movement of chemical agents—poison gas. I was assured that:

> Movement of chemical agents is governed by rules and procedures established by the ICC and the U.S. Public Health Service.
>
> * * * * * * *
>
> In the unlikely event of accidental discharge in a city or town, the first steps would be to secure the area; to decontaminate the liquid material, and to provide first aid to any individuals who came in contact with the liquid. Supplies are carried in the train to accomplish this. Any alkaline material, such as bleach or quicklime, will rapidly decompose nerve agents.

When I subsequently learned that the Army planned to move 4,000 tons of mustard gas, 2,500 tons of Air Force nerve gas bombs, and some other nonlethal gases by train to Earle, N.J., I was told that it would take 68 months to dispose of the gas at the arsenals where it is stored. I also found out that no special permit is required to move nerve gas bombs by rail, although a special Bureau of Railway Safety permit is required to move mustard gas in cylinders if the cylinders have not been tested in the past 5 years. The planning and coordination of the proposed move of poison gas by the Department of Defense convinced me more than ever that hard questions must be asked concerning the gas and germ warfare testing activities of the Armed Forces.

One of the first questions that must be asked is why must there be field testing of chemical and biological warfare agents? The Defense Department states that it is our policy to develop and maintain a limited offensive capability in order to deter all use of CB weapons by the threat of retaliation in kind. Normally, development of such a capability involves the field testing of weapons systems so that we know their effectiveness. With the exception of Yemen and Vietnam, there has been no recorded use of gas in the last two decades. The only large scale use of gas occurred in World War I with agents that are now out of date. There has been no recorded use of biological warfare in the 20th century. This lack of experience places pressures on the Department of Defense to test their new weapons.

There are, of course, weapons that we do not test today because of the danger of testing to the public. I refer to atmospheric testing of nuclear weapons. Most major nations do all testing of these weapons underground because of the dangers to the public from atmospheric fallout. This has meant that certain warheads and weapons systems in our arsenal must be tested within laboratories and enclosed test chambers or on a theoretical basis in the interests of public safety. I think it is appropriate to ask whether gas and biological warfare agents should be similarly restricted? I, for one, believe that this restriction should definitely be placed on biological warfare agents. And unless I can receive the assurance of highly qualified non-Government scientists and doctors that gas tests are to be conducted under the most stringent safety conditions, I believe that the same restrictions should be placed on the testing of the highly lethal poison gases.

How does the Army's test record of CB agents stack up? On March 13, 1968, the U.S. Army tested VX nerve gas at the Dugway Proving Ground, Dugway, Utah. An Air Force plane released VX from a spray tank at the correct altitude. Yet when the pilot attempted

to stop spraying he was unable to cut it off. The gas continued to spray out of the tank as the plane gained altitude. The gas was then carried by winds outside of the boundary of the proving ground onto adjacent grazing lands used by Utah sheepherders. The next day sheep began to die. Eventually about 6,400 died.

On March 20, 1968, the Dugway public information officer, Tom Donnelly, denied that Dugway was running any tests that would cause the sheep deaths. Yet the next day, Senator Frank E. Moss of Utah received from the Defense Department confirmation of the VX test. On March 24, 1968, an anonymous spokesman at Dugway denied that there was any connection between Dugway's activities and the sheep deaths. Even the report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground, published in November 1968, did not say that the nerve gas test was responsible for the accidental death of the sheep. This ad hoc committee, incidentally, was headed by Surg. Gen. William H. Stewart of the U.S. Public Health Service.

(The "Report of the Interagency Ad Hoc Committee for Review of Testing Safety at Dugway Proving Ground," Department of the Army, November 1968, is reprinted in the appendix of this hearing record, page 187.)

And in Defense's reply to my March 7, 1969, letter, Dr. Foster [Dr. John S. Foster, Director of Defense Research and Engineering, Department of Defense] says:

"With regard to the extremely unfortunate Skull Valley incident, the exact chain of events is still not completely understood. A freak meteorological situation was probably a major contributing factor."

I do not consider this evasion acceptable. If the incident is not completely understood, there should be no further testing until it is.

I understand, however, that the National Communicable Disease Center of the U.S. Public Health Service in Atlanta, Ga., identified the substance found in the sheep as the same as VX.

(The National Communicable Disease Center report, "Investigation of Sheep Deaths—Skull Valley, Utah," appears in the appendix of this hearing record, p. 246.)

I further understand that their investigators at Dugway expressed concern that the effects of the VX nerve gas, sprayed in a 100-mile cone, would last anywhere from 2 to 3 years. And I am further informed that tests of sheep at different points around Dugway showed that all of them had received low-level exposure to nerve gas at some time. This information has not been made available to the public. I think that a full statement by the U.S. Public Health Service on the sheep-kill, based on its investigations rather than those of the ad hoc committee, is called for.

I think that this separate report is necessary for the following reasons: Only 10 months before the Skull Valley sheep-kill the U.S. Army issued Army Regulation No. 11-17. The title was "Chemical and Biological Weapons Surety Program." The regulation stressed the need to observe strict safety precautions, stating that:

> It is important, therefore, that no lapse or failure occur in security and safety measures and controls; and that effort be directed to the detection of gaps and deficiencies in these controls and to the improvement of safety and security controls in all functional and administrative areas concerned.

Only 10 months later the Skull Valley sheep-kill occurred. And in the same year there were three recorded leaks of phosgene gas being transported through major cities. So when the U.S. Army tells me that a special Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground has made recommendations that are now being observed, I do not find that a satisfactory answer. My worries are further increased when I find that the ad hoc committee did not consider testing new agents—that is, agents of a new characteristic. Does this mean that toxins, the byproducts of biological agents, which are sometimes not classified as biological agents and are sometimes more deadly than nerve gas, will be tested at Dugway? Does it mean that the ad hoc committee made no recommendation concerning the testing of toxins?

One further remark concerning the Skull Valley skeep-kill should be made. I was informed by one of the two Federal officials that confirmed the information I had received about the cross-country movement and disposal plans for poison gas, that 1,700 head of cattle were killed by the VX nerve gas test. This has subsequently been disputed by the U.S. Army. When I rechecked this with the official in question, he said he wasn't absolutely certain but that "he was pretty sure." I believe that an independent report by the U.S. Public Health Service should determine whether cattle as well as sheep were killed.

I do not find a safety committee made up of University of Utah scientists and State of Utah officials a satisfactory answer to the problems of testing safety at Dugway. Tests conducted there have implications for all Americans. A broadly based safety group is needed.

On a more permanent basis, I believe that a testing safety committee made up of independent—that is, non-Government—members be set up to monitor the safety of chemical and biological warfare testing by the United States. I believe that it should be composed of scientific experts appointed by nationally known organizations such as the National Academy of Sciences. It should be composed also of doctors representing several of the various doctors' organizations. It should include eminent citizens, perhaps appointed by the White House. And it should include several Members of Congress other than those that regularly deal with chemical and biological warefare activities. A broadly representative group such as this could give the assurance of safety needed by the public.

I have reserved my remarks concerning testing of biological agents until the last because I believe that they should be treated separately. I am of the opinion that the active testing of biological warfare agents is as dangerous to the United States, and for that matter the world, as it is to a potential enemy. Tularemia, a disease that is not generally fatal—only 5 to 8 percent of those infected die—can be spread by a single organism compared with the several thousand organisms required to spread most diseases.

Psittacosis or parrot fever, a highly infectious disease, has recently appeared in Baltimore. If untreated, it can cause 10 percent fatalities. Since it is sometimes carried by parrots and parakeets, Maryland has considering banning these birds from the State. Yet this disease has been intensively studied at Fort Detrick, Md. And a researcher at the University of Utah was singled out for praise for his discovery that

"there is another mode of transmission for the disease commonly called psittacosis or parrot fever."

Experimenting with these diseases is not as simple as it might seem. So-called incapacitating biological agents—that is, diseases that are generally not lethal—are very frequently lethal to the very young, the old, and the sick. And a disease that may start out in a mild form when first tested, may become a highly deadly disease if it spreads. A disease that is mild may mutate as it passes through several different areas and become more deadly. By the time health officials caught up with it, they might not have any vaccines that would be effective in treating the new mutation. And, of course, I refer here to diseases that are mild in origin. Many of the diseases developed by the Army are vaccine-resistant strains, deliberately bred to resist treatment. Dr. Foster, in his reply to my March 7, 1969, letter, said that there were many biological agents for which there are no toxins. He furthermore says that there are no means of knowing when biological agents are being spread over an area other than the outbreak of the disease. In effect, there is no civil defense against biological weapons. This applies, equally in my judgment, to defense against a test that results in a major accident.

Dr. Joshua Lederberg, Nobel laureate biologist at Stanford University, has warned of a pandemic—a worldwide epidemic—if one of these tests should get out of hand. He cites the case of Marburgvirus, a disease apparently carried by the green monkey, that almost got out of hand in Europe. It infected 32 people, killing five, before it was fortunately recognized by a germ warfare expert and isolated. He says that it could have swept through London, then around the world, possibly causing as many as a half billion casualties. This is the nature of the biological agents that we are working with.

Information on atmospheric testing of biological agents is limited at best. Defense releases almost no information on the subject. It is known, however, that:

1. The British tested anthrax on the Scottish island of Gruinard early in World War II. An investigation by scientists in 1966 showed that the island was still contaminated and probably would remain contaminated for 100 more years.

2. The U.S. Army apparently tested botulism on Horn Island in the Gulf of Mexico off Mississippi during World War II.

3. The U.S. Air Force vicinity map of Wendover Air Force Range (July 1967, Tab NR R–1), connected to the Dugway Proving Ground, shows an area described as "Permanent Bio Contaminated Area," located in township 7 south, range 16 west, Salt Lake Meridian, Utah. The map also shows "Granite Peak Range BW plots," located in township 8 south, range 14 west. The map also shows a "toxic disposal" area, located in township 9 south, range 10 west.

4. The Army's contract with the University of Utah's ecology and epizoology group called for the production of antigens—substance that will stimulate the production of an antibody—for Venezuelan equine encephalomyelitis, Western equine encephalomyelitis, and one other disease, for field testing by Dugway personnel. These antigens would be necessary for the protection of test personnel or to prevent the spread of a disease by animals. I do not know whether field testing

takes place at Dugway, Fort Greeley, Alaska, in the Pacific, or in Australia. But I believe that it is conducted at one or more of these locations.

5. The antigen that is produced by an animal that has come in contact with VEE has been found in animals around Dugway. Prior to this time VEE has been limited to the rat population of Florida. This suggests that VEE has been tested either in the open at Dugway or at its laboratories and has transferred to the animal population. One way to determine whether VEE is found only around Dugway or is now generally found around the United States would be to test the rat population in several States between Utah and Florida and see whether VEE has spread north from Florida. This could very well be one of the jobs of the special task force that I have asked Secretary of Health, Education, and Welfare Finch to set up to study biological testing safety at Dugway.

6. The Illinois Institute of Technology Research Institute in Chicago contracted with Fort Detrick to do a comprehensive series of reports on the aerobiology of various agents. Three reports summarize studies with VEE virus. One of these presents detailed studies on the characterization of airborne VEE virus. IITRI's speciality in chemical and biological warfare research is the distribution of bacteria through aerosols—that is, a suspension of fine solids or liquids in a gas.

In my letter to Secretary Finch of May 8, 1969, calling for an investigation of the biological warfare testing program and its possible implications for public health in the United States, I stated that I had been informed that VEE had apparently been tested at Dugway. The Air Force map convinces me that biological testing has been conducted at Dugway but whether VEE was the biological agent tested is open to question. In view of the presence of antigens that would normally be found in animals infected with VEE in the animal population around Dugway, and the indications of biological testing at the proving ground, I again urge Secretary Finch to conduct such an investigation so that the American public can be assured that testing does not endanger the health of the Nation.

Going beyond this investigation, though, I also question whether the United States should test biological agents in the atmosphere at all, either in the United States or abroad. In my mind the dangers are too great. If we must test these agents, the tests should be conducted within laboratories or in laboratory chambers—not in the atmosphere. Only the strongest reassurance as to safety from independent experts such as Dr. Lederberg and Dr. Barry Commoner can convince me otherwise.

Mr. REUSS. Thank you, Representative McCarthy.

On page 2 of your statement you referred to some of the history of chemical and biological warfare. You say there has been no recorded use of biological warfare in the 20th century.

Has there ever been any recorded use of biological warfare?

Mr. MCCARTHY. Going back into ancient history there was intimation in Homer that they did use it back in the times of the Athenians and the Spartans and that horses were infected with the disease. Through the Roman period there were some intimations in Caesar——

Mr. REUSS. Homer didn't identify this as equine encephalitis. [Laughter.]

Mr. MCCARTHY. No.

Mr. REUSS. Any other references?

Mr. MCCARTHY. Through history there have been sporadic reports that armies use these to infect horses. That is the only use of germ warfare that I have come across.

Mr. REUSS. Now, you referred to the recorded use of chemical agents in the last two decades. You say with the exception of Yemen and Vietnam no use has been recorded.

What occurred in both of those places and who are responsible for it?

Mr. MCCARTHY. Well, let me enlarge that a little and bring it to modern times.

There have been four cases in modern times. One was the use of gas against the Ethiopians by the Italians. The second was by the Japanese against the Chinese.

Mr. REUSS. What were those agents?

Mr. MCCARTHY. These were gases. I am sorry, I don't have the exact gas that was used. I believe that the information is available.

I have gone into the use in Yemen in more detail. They used several types, including a lethal gas—that is, UAR did against the Yemeni Royalists.

In Vietnam of course we have used three types of chemical warfare. We have a defoliation program. We have an antifood program that is to destroy food grown by the enemy. Thirdly, we have, for several years now, used gas—three types have been used there. One is CN, which is a tear gas. Another is CS, also a tear gas, which is most generally used and is still being used. The third type was DM, a very strongly toxic vomiting agent called adamsite.

We have used three variations of CS: CS, CS–1 and CS–2. These have been used in various ways. One that has been elaborately reported is the use of it in advance of a B–52 raid to drive the enemy personnel out of their bunkers so they could be hit by the bombs.

Mr. REUSS. You state that the Defense Department says it is our policy to develop and to maintain a limited offensive capability in order to deter the use of chemical and biological weapons by others.

Who, according to the Pentagon, is known to possess chemical and biological weapons?

Mr. MCCARTHY. Well, Mr. Chairman, some of that is classified but I believe that it is general knowledge that the Soviet Union has a capability in this field. China has a rather infant capability. Other Western nations—West Germany, Spain, Great Britain, Australia, and Canada. There are a number that have capabilities of varying degrees in this area.

Mr. REUSS. What international treaties or conventions, if any, are there which govern the use of chemical and bacteriological warfare?

Mr. MCCARTHY. The Geneva Protocol of 1925 has been ratified by 62 nations. This is a "no first use" treaty: The signatories agree not to use these weapons unless somebody else uses them against them first. All NATO nations, except the United States and all Warsaw Pact nations including the Soviet Union plus Red China, ratified this

document which the United States initiated after World War I. We actually ratified almost the exact wording in 1922 in another treaty but it never became operative because the French objected to a provision on submarines. When it came up again in 1926 the proponents were complacent and an intensive lobbying effort was launched by the chemical industry in the United States and the protocol was never ratified.

Presidents Roosevelt, Hoover, and Coolidge all said we would adhere to it even though the Senate hadn't ratified it. President Roosevelt stated this very categorically during World War II. This was observed by all the combatants in that war but there has been, as I replied to your question earlier, an erosion in recent years and I lament this very much.

I feel this protocol could be a building block for peace. It is the only case I know of where civilized men have agreed that a certain group of weapons will be excluded as being outside the pale. For that reason I have urged President Nixon to resubmit this protocol to the U.S. Senate.

The chairman of the Foreign Relations Committee has agreed with this and hopes the President will and hopes that it would be ratified belatedly.

Mr. REUSS. Was it voted on?

Mr. MCCARTHY. It was never voted on. Senator Borah of Idaho, when he perceived the opposition, just withdrew it. It was voted out of his committee but it was never taken on the floor for a vote. Then it gathered dust for many years. When Senator Vandenberg became chairman of the Foreign Relations Committee, he sent a number of treaties back to the President as a housekeeping thing only. He came in and saw all these treaties and said, well, let's get some order here. What should we do? The State Department said, send them back to the White House. It was withdrawn, in the lawyer's terminology, without prejudice so that it was never really rejected.

Mr. REUSS. Mr. Vander Jagt.

Mr. VANDER JAGT. Thank you, Mr. Chairman.

I would like to thank Congressman McCarthy for appearing here. I have been very impressed with your encyclopedic knowledge of this subject and would like to inquire how your interest in this subject began?

Mr. MCCARTHY. Well, I was just sitting home with my wife watching television and we saw this NBC program, February 4, "First Tuesday," in which they devoted almost an hour to this and it was a rather gripping and shocking presentation. She asked me "Well, you are a Congressman; what do you know about this?" I said, "nothing."

So I set out to inform myself.

Mr. VANDER JAGT. I think that demonstrates not only the power of television but the power of a wife.

Mr. MCCARTHY. She is here today, too.

Mr. VANDER JAGT. She is to be congratulated for the stimulation of your interest on this subject.

On page 2 you bring out something that was new to me and that was the report of the possibility of 1,700 cattle being killed as well as the over 6,000 sheep.

Can you identify for us the Federal official who has indicated this?

Mr. McCarthy. I will tell you what I would like to do on that. I will be happy to give that to you in executive session. This man's job is in jeopardy. He is one of the ones who told me about the cross-country train-ship disposal plan and I have confidence in his accuracy because that information proved out to be about, well, over 95 percent accurate. I would be happy to do that in executive session and you could call him if you wish.

Mr. Vander Jagt. That is very satisfactory to me.

I am extremely interested, though, because he says he is pretty sure; I think it is something we should explore and get the answer to, but that is satisfactory to me.

Mr. McCarthy. I certainly agree. You understand, this information is hard to come by. I am not saying that, you know, this is 100 percent. It is very hard to get this information. But I am willing to have this and anxious to see it reviewed by your subcommittee and have also suggested to Secretary Finch that he make a thorough-going inquiry into this thing.

Mr. Vander Jagt. Thank you. I have no further questions.

Mr. Reuss. Mr. Gude?

Mr. Gude. Mr. McCarthy, in the first page you discuss the letter from Secretary Laird and in the letter you have the quotation, "In the unlikely event of accidental discharge in a city or town, the first steps would be to secure the area," and so on.

In your research or in this letter, was it determined who would have made the necessary steps prior to the shipment of the gas, so that should you have an accident these steps would be taken to provide first aid? What agencies would do this? Is this the U.S. Public Health Service?

Mr. McCarthy. The Army.

Mr. Gude. The Army?

Mr. McCarthy. Yes.

Mr. Gude. They would have the facilities traveling on the train with the gas and would be——

Mr. McCarthy. Yes. They said they would have guards on the trains at the front and the rear and in the middle, but frankly I don't think this would be much of a protection if one of these containers ever was ruptured. You are talking about a material one-fiftieth of a drop of which will kill you in seconds just on contact with your skin. It doesn't do much good to give somebody an antidote after he has got VX on his skin because he will be dead.

Mr. Gude. Well, you read occasionally of a tank of chlorine or ammonia rupturing and towns have to be evacuated and medical authorities are equipped and have an idea of what to do in dealing with these materials; but this would be traveling through my town and if a tank ruptured, what—I mean it is fine to say the first steps would be to do these things but I was wondering who would do them and how they would get the knowledge.

Mr. McCarthy. Well, you would have to have an intensive education program. The Army personnel would have to educate the medical personnel. I think you can see that it really is sort of optimistic to think that such a plan could be put into immediate effect in the event of a collision, and this was my main concern.

These trains would not usurp this section of track. There would be other trains permitted to go in the other direction or in the same direction, adjacent. In an environment of increasing railroad accidents—100 percent increase in derailments between 1961 and 1968—as you know. This is a matter just on its own, exclusive of nerve gas, that requires our attention and I understand the chairman of the Commerce Committee is going to have hearings on this subject of railroad safety. I think the hazards of moving poison gas by military outweigh the advantages of this plan and I think one factor, one that you have drawn attention to, is the matter of first aid and efforts to decontaminate the material after an accident.

Mr. GUDE. Thank you very much.

Mr. REUSS. Counsel, do you have any questions?

Mr. INDRITZ. Congressman McCarthy, would you provide for the record copies of your correspondence with the Defense Department that you referred to in your testimony?

Mr. MCCARTHY. Yes; Mr. Indritz, I would be happy to.

(The correspondence follows:)

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., Mar. 7, 1969.

Hon. MELVIN R. LAIRD,
Secretary of Defense, Department of Defense,
Washington, D.C.

DEAR MR. SECRETARY: Recently my lack of knowledge of U.S. programs and policies in the fields of chemical and biological warfare was brought home to me. I realized that I did not know, as I did concerning our ICBM's, our B–52 bomber force, our troops deployed in Germany or Vietnam, the basic reasons for these programs. I also did not know the policies that guide our use or nonuse of weapons in these areas. And I did not know what safeguards are being taken to protect the American public from any danger from activities in these areas.

With the advice of my colleagues from New York State on the Armed Services Committee of the House, I asked the U.S. Army to give me and any other interested colleagues in the House and Senate a briefing on the basic reasons for, the safeguards, and the public policies that applied in the fields of chemical and biological warfare.

Apparently my interest was shared by many other Members of Congress for 19 Members, three Senators, and 16 representatives from Members' offices attended the briefing which was held on March 4, 1969. The number of staff would certainly have been larger had attendence, even for the unclassified portions of the briefing, not been restricted to those with active security clearances.

In discussing the nature of the briefing with the U.S. Army, I asked that the basic public policies governing our activities in the chemical and biological warfare fields be covered in the nonclassified section of the briefing. I stressed that our national capabilities and policy in this area should be subject to the same discussion, public review, and constructive criticism as are our ICBM, Polaris fleet, F–111 bomber program, and ABM system. I deliberately refrained from raising questions which I believed would legitimately fall within the area of secrecy.

Gen. James A. Hebbeler presented a briefing that was informative and interesting to those attending. But many of the public policy questions remained unanswered. I am therefore sending to you for reply a list of the public policy questions, the answers to which are essential to an intelligent and rational appraisal by Members of Congress and the concerned public toward these programs. I would appreciate your considered answers to these questions:

1. Is it our national policy to respond in kind to a gas attack against the Nation? Do we state that we will use lethal gas against a nation that launches a gas attack against us, rather than a nuclear attack? Wouldn't it be cheaper and just as effective to retaliate with another weapon with which we have had operational experience?

2. Is it our national policy to respond in kind to a massive biological weapon attack? Wouldn't it be cheaper and infinitely safer for all of mankind to respond to a biological weapon attack with other weapons with which we have had operational experience?

3. If our gas biological warfare efforts are purely defensive in nature, what steps have been taken to defend our public from these threats? Why hasn't the public been instructed as to what to do in the case of a nerve gas attack, a hallucinatory gas attack, or an incapacitating gas attack? Do we stockpile antidotes, serums, and vaccines for gas and biological attacks at medical centers and instruct people where they are? We do, after all, instruct people what to do in the case of nuclear attack. We stockpile supplies in fallout shelters that are marked so that the public will know where they are. Why don't we do the same for the threat from gas and biological weapons?

4. We have been told by former Under Secretary of Defense Cyrus Vance, that the "why" of chemical and biological warfare is defense. Are our soldiers in the field, Vietnam, Korea, Germany, and sailors at sea able to defend themselves against all forms of chemical and biological weapons attack? Since we are using marginal forms of a chemical warfare in Vietnam, are our forces prepared for an escalation in the use of chemical weapons? Are our troops prepared for the possibility of the enemy responding with a stronger weapon than the incapacitating gases we use?

5. Why do we choose to call defoliants herbicides of the type we use in our own agriculture rather than chemical warfare? What defoliants or chemicals, if any, are being used in Vietnam to destroy plant life which are not customarily used in the United States? To what extent are they used? What is the distinction between a chemical that is used to destroy crops and a plant disease from the field of biological warfare that could be used against rice or wheat?

6. Do we have in practice or in policy an antifood policy through the use of defoliants in Vietnam? What are our plans to restore the environment of Vietnam which has been significantly altered as a result of our defoliant policy? Will we establish a commission similar to the Atomic Bomb Casualty Commission that operated in Nagazaki and Hiroshima after the war to study and correct some of the damage that we caused?

7. Why do we exclude incapacitating gases such as those used in combat operations in Vietnam from the chemical warfare category? Why are vomiting gases, incapacitating gases, and other irritants regarded as being different from other forms of gas? Apparently we have a policy of using nonlethal, or at least nonlethal by intent, gas in combat. Are there occasions under which the gases in use are or have been lethal? Under Secretary Vance has said that these gases are not chemical warfare because they are used by police for riot control and the like. Even if they are, this still appears to be a policy of using incapacitating agents as an offensive weapon. Any distinction made by Secretary Vance is semantic and once again opens the credibility gap.

8. What precautions are taken to insure that chemical and biological warfare experiments are of no danger to the public? What precautions did not work at the sheep-kill at Skull Valley in Utah? What precautions are taken when the Army moves chemical agents from a plant to a storage depot or to a port of embarkation or an airfield? What are the risks if there is a train wreck? Are the agents being transported volatile? Are they inert? Are the chemicals moved in tanks under pressure? Is the statistical probability of an accidental discharge of poisonous chemicals greater than of the probability of a nuclear explosion from, say, an ABM warhead? What can be done to counter the damage that would be done if there were an accidental discharge of a chemical agent while in transit through a city or town?

9. What is the annual cost of our activities in the fields of chemical and biological warfare? What is the cost of munitions and weapons in these fields? Since comparable figures are available for our procurement and research programs on ICBM's, the ABM, Polaris, and similar forces, I can assume they can be made available for our CBW program. If they can't, why can't they?

10. Do we have the capability to respond to a massive nation-wide gas or biological warfare attack? That is, could we launch a similar and immediate attack against the aggressor? The deterrent effect of our ICBM's is based on the enemy's knowledge that we can and will respond. This has been a policy publicly stated by the Secretary of Defense. Is the same true in the fields of chemical and biological warfare?

11. Do we have a rapid warning system that will alert the public to a chemical or biological attack?

12. Does the Army use any discretion as to what types of institutions should be encouraged or pressed into accepting funds for work in chemical and biological warfare? Does the Army see any conflict in asking a purely civilian institution, such as the Smithsonian, to do work that might conflict with the institution's activities abroad.

13. Would the United States or any major nation be risking its national security by dispensing with chemical and biological weapons altogether, especially in view of their many skills with weapons that have already been used?

14. Isn't it correct, as Dr. Joshua Lederberg has said, that biological weapons are regarded as a tool of dubious value at best?

Sincerely,

RICHARD D. MCCARTHY,
Member of Congress.

APRIL 15, 1969.

Hon. RICHARD D. MCCARTHY,
U. S. House of Representatives,
Washington, D.C.

DEAR MR. MCCARTHY: The Secretary of Defense has asked me to reply to your letter of March 7, 1969, concerning chemical and biological warfare.

Answers to each of your questions are attached. Copies of reports and other materials which are relevant to the questions are included. It is believed this information responds to your inquiries on an unclassified basis. There are areas which could be extended and amplified by classified discussion.

Sincerely,

JOHN S. FOSTER, JR.,
Director of Defense,
Research and Engineering.

Question 1. Is it our national policy to respond in kind to a gas attack against the Nation? Do we state that we will use lethal gas against a nation that launches a gas attack against us, rather than nuclear attack? Wouldn't it be cheaper and just as effective to retaliate with another weapon with which we have had operational experience?

Answer. It is the policy of the United States to develop and maintain a defensive chemical-biological (CB) capability so that our military forces could operate for some period of time in a toxic environment if necessary; to develop and maintain a limited offensive capability in order to deter all use of CB weapons by the threat of retaliation in kind; and to continue a program of research and development in this area to minimize the possibility of technological surprise. This policy on CB weapons is part of a broader strategy designed to provide the United States with several options for response against various forms of attack. Should their employment ever be necessary, the President would have to authorize their use. The United States does not have a policy that requires a single and invariable response. Deterrence is our primary objective.

Chemical weapons, in many tactical situations, are more effective than conventional (high explosive and projectile) weapons. Accordingly, it is believed wise to deter their use. If two approximately equally effective military forces were engaged in combat, and one side initiated a CB operation, it could gain a significant advantage even if the opposing side has protective equipment. Neutralization of this advantage could not be achieved with conventional arms.

Question 2. Is it our national policy to respond in kind to a massive biological weapon attack? Wouldn't it be cheaper and infinitely safer for all of mankind to respond to a biological weapon attack with other weapons with which we have had operational experience?

Answer. The U.S. policy and its rationale with regard to biological warfare is generally the same as that for chemical. As a matter of policy the United States will not be the first to use biological weapons, but we are aware of the capabilities these weapons place in the hands of potential adversaries. For this reason it is important to carry on our R. & D. program in BW, not only to provide necessary equipment, such as detection and warning devices, but to define and quantify more fully the potential threat to the United States from these weapons, and the hazards involved if they are ever used against us.

Question 3. If our gas biological warfare efforts are purely defensive in nature, what steps have been taken to defend our public from these threats? Why hasn't the public been instructed as to what to do in the case of a nerve gas attack, a hallucinary gas attack, or an incapacitating gas attack? Do we stockpile antidotes, serums, and vaccines for gas and biological attacks at medical centers and instruct people where they are? We do, after all, instruct people what to do in the case of nuclear attack. We stockpile supplies in fallout shelters that are marked so that the public will know where they are. Why don't we do the same for the threat from gas and biological weapons?

Answer. The threat to the U.S. civil population from CB attack has been studied by the Department of Defense, and these analyses are periodically updated. It is clear that the threat of CB attack is less significant than that of nuclear attack. For this reason, more emphasis has been placed in civil defense on the nuclear threat.

For logistic reasons chemical agents do not appear to pose a major strategic threat against the United States. For example, it would require many tons of nerve agent munitions to carry out an effective attack against a city of a few million people. This may appear inconsistent with the high toxicity of the nerve agents, but for many technical reasons, such as the difficulty in disseminating the agents in vapor or aerosol form, the dilution of the agent in the atmosphere, and their impingement on ground and vegetation, it is correct. For this reason, the United States does not maintain stockpiles of therapeutic materials for nerve agents. Although the possibility of the employment of biological weapons against U.S. population centers cannot be ruled out entirely, it does not presently warrant the priority given to defense against the effects of nuclear weapons. Research on methods of detecting and warning, identifying, and defending against biological attack are continuing, as is the review of the magnitude and nature of the threat.

The Office of Civil Defense has developed an inexpensive but effective protective mask for civilian use, and a limited production run was made to test production quality. No large-scale production was undertaken because of the low estimate of the threat as described above. Should the threat to the U.S. population increase, this mask could be produced quite rapidly and, together with other necessary defensive measures, would afford protection against both chemical and biological attack. Filtration systems have been designed and tested, and these could be added to fallout shelters to afford collective protection for groups of people. In addition, many of the emergency plans developed by the Department of HEW for postnuclear attack medical support would be applicable. The emergency packaged hospitals, for example, provide for expansion of hospital facilities by the equivalent of 2,500 hospitals of 200-bed size.

The United States does not maintain large stockpiles of medical supplies such as antibiotics and vaccines against the possibility of biological attack. There is no specific antibiotic therapy available for most BW agents. As for vaccines, there are more than 100 possible BW agents, and production and administration of 100 vaccines to the U.S. population is not practical. There is medical reason to believe that such a program would be generally injurious to health in addition to requiring prohibitive expenditures.

Question 4. We have been told by former Under Secretary of Defense Cyrus Vance, that the "why" of chemical and biological warfare is defense. Are our soldiers in the field, Vietnam, Korea, Germany, and sailors at sea able to defend themselves against all forms of chemical and biological weapons attack? Since we are using marginal forms of a chemical warfare in Vietnam, are our forces prepared for an escalation in the use of chemical weapons? Are our troops prepared for the possibility of the enemy responding with a stronger weapon than the incapacitating gases we use?

Answer. The U.S. Armed Forces have the equipment to protect themselves against CB attack with the exception of a biological warning and detection device which is under development. U.S. soldiers and sailors generally have masks and protective clothing; and collective protection equipment for vans and communication centers is being developed and supplied. U.S. troops in Vietnam are prepared for possible enemy uses of chemical weapons.

Question 5. Why do we choose to call defoliants herbicides of the type we use in our own agriculture rather than chemical warfare? What defoliants or chemicals, if any, are being used in Vietnam to destroy plantlife which are not customarily used in the United States? To what extent are they used? What

is the distinction between a chemical that is used to destroy crops and a plant disease from the field of biological warfare that could be used against rice or wheat?

Answer. There are no herbicidal chemicals used in Vietnam to destroy vegetation which have not been widely used in the United States in connection with clearing areas for agricultural or industrial purposes.

The term "defoliants" is used because it properly describes the purpose of its use; that is, to remove leaves from jungle foliage to reduce the threat of ambush and to increase visibility for U.S. forces. This use of defoliants has saved many American and South Vietnamese lives.

There are several distinctions between a chemical herbicide and a biological plant disease. The biological agents are living plant pathogens, and may be spread beyond the area of attack by winds, insects, or animals. Chemical herbicides do not spread in this manner beyond the area of attack. Further, more is known about the effects of chemical herbicides because of their widespread use throughout the world. Each use of herbicides or defoliants in Vietnam is approved by the U.S. Embassy and the Government of the Republic of Vietnam.

Question 6. Do we have in practice or in policy an antifood policy through the use of defoliants in Vietnam? What are our plans to restore the environment of Vietnam which has significantly altered as a result of our defoliant policy? Will we establish a commission similar to the Atomic Bomb Casualty Commission that operated in Nagasaki and Hiroshima after the war to study and correct some of the damage that we caused?

Answer. The United States has a carefully limited operation in South Vietnam to disrupt the enemy's food supply. It is limited to the attack of small and usually remote jungle plots which we know the VC or NVA are using. Usually these plots are along trails or near their base camp areas. Each such operation is approved by the U.S. Embassy and the Government of the Republic of Vietnam. Enemy caches of food, principally rice, are also destroyed when it cannot be used by the South Vietnamese. These limited allied activities have never, in any single year, affected as much as 1 percent of the annual food output of South Vietnam.

To date surveys have shown that there is no evidence of substantial permanent or irreparable damage from the viewpoint of the future development of South Vietnam, attributable to the defoliation effort. The Department of Defense has supported the Department of Agriculture in studies of herbicides in analogous areas, and I am attaching a copy of their report "Response of Tropical and Subtropical Woody Plants to Chemical Treatments." The Department of Defense also had a base line study of the forests of Vietnam prepared entitled "Forests of Southeast Asia, Puerto Rico, and Texas," a copy of which is attached. More recently a study "Assessment of Ecological Effects of Extensive or Repeated Use of Herbicides" was done by Midwest Research Institute, a copy of which is attached. This study was reviewed by a special committee of the National Academy of Sciences, and judged by them to be an accurate and competent report. Last fall, the Department of State, with Department of Defense participation, made a survey of the ecology of defoliated areas. One of the scientists who made this survey, Dr. Fred Tschirley from the Department of Agriculture, published his report in Science. A copy of his report is attached.

At the end of active combat, it appears probable that there will be agricultural and forestry activities and other programs which will aid the South Vietnamese people. The Department of Defense would cooperate with the Department of State and the U.S. Agency for International Development as necessary in accomplishing these. The Department of Defense supports the concept of a comprehensive study of the long-term effects of the limited defoliation program, and has endorsed, in principle, proposals by the American Association for the Advancement of Science for such a scentific study.

Question 7. Why do we exclude incapacitating gases such as those used in combat operations in Vietnam, from the chemical warfare category? Why are vomiting gases, incapacitating gases, and other irritants regarded as being different from other forms of gas? Apparently, we have a policy of using nonlethal, or at least nonlethal by intent, gas in combat. Are there occasions under which the gases in use are or have been lethal? Under Secretary Vance has said that these gases are not chemical warfare because they are used by police for riot control and the like. Even if they are, this still appears to be a policy of using incapacitating agents as an offensive weapon. Any distinction made by Secretary Vance is semantic and once again opens the credibility gap.

Answer. The only "incapacitating gas" in use by U.S. Forces in Vietnam is the riot control agent called CS, although CN was also authorized some years ago. Both are tear gases. There is no known verified instance of lethality by CS, either in Vietnam or anywhere else in the world where it has been used to control disturbances by many governments.

Efforts to find the statement you attribute to the former Deputy Secretary Vance have been unsuccessful. A copy of an excerpt from his testimony 2 years ago before the Disarmament Subcommittee of the Senate Foreign Relations Committee (February 1967) is attached. The distinction he made is that the United States has never used biological weapons, nor have we used lethal chemical weapons since World War I, and that it is against U.S. policy to initiate their use, but that the United States has used riot control agents and herbicides. It is believed these distinctions are still valid.

Question 8. What precautions are taken to insure that chemical and biological warfare experiments are of no danger to the public? What precautions did not work at the sheep-kill at Skull Valley in Utah? What precautions are taken when the Army moves chemical agents from a plant to a storage depot or to a port of embarkation or an airfield? What are the risks if there is a train wreck? Are the agents being transported volatile? Is the statistical probability of an accidental discharge of poisonous chemicals greater than of the probability of a nuclear explosion from, say, an ABM warhead? What can be done to counter the damage that would be done if there were an accidental discharge of a chemical agent while in transit through a city or town?

Answer. Strict safety practices are enforced at laboratories which do research on CB agents. Elaborate systems of airtight hoods, air filtration and waste decontamination are employed. These precautions and procedures are reviewed by the U.S. Public Health Service as well as by Department of Defense safety experts. The equipment and building designs developed at the U.S. Army Biological Laboratories, for example, have been generally accepted throughout the world as the ultimate in safety for the investigation of infectious diseases.

With regard to the extremely unfortunate Skull Valley incident, the exact chain of events is still not completely understood. A freak meteorological situation was probably a major contributing factor. This matter has been carefully reviewed by a special advisory committee appointed by the Secretary of the Army and chaired by the Surgeon General of the U.S. Public Health Service. A copy of this report is included for your information. This committee has made a number of recommendations concerning test limitations, toxicological and environmental investigations, added meteorological facilities, and a permanent safety committee. All of these recommendations are being followed.

Movement of chemical agents is governed by rules and procedures established by the Interstate Commerce Commission and the U.S. Public Health Service. The material is shipped in special containers; these containers are put on pallets if necessary and fully restrained, and an underlying layer of sand is used to reduce vibration and to absorb agent in the highly unlikely event of leakage. All shipments are accompanied by a trained escort detachment equipped with decontaminating and first aid equipment. Routes are carefully planned to avoid populated areas to the greatest extent possible; and, where they cannot be avoided, to move through them carefully and with as little delay as possible.

The precautions taken—the use of special trains, careful routing, controlled speeds, and other measures—make a train wreck extremely unlikely. However, even further steps are taken to minimize any hazard that might result from an accident. Buffer cars are included in the train, the escort detachment is distributed in different cars to provide prompt full-train coverage in emergencies, and transit time through populated areas is minimized. Although the agents are not inert, it is important to note that transported agents are neither volatile nor in the gaseous state. They are liquid, and the most volatile is about eight times less volatile than water. The containers are not under pressure, and nerve agents are rapidly rendered harmless by fire.

The comparison of statistical probabilities of a railroad accident and subsequent discharge of chemicals or accidental explosion of a nuclear device is very difficult because of the differences between them. Extensive precautions are taken to provide safety in both. There has never been either an accidental nuclear explosion or an accidental discharge of chemical agent during shipment. This absence of data makes it impossible to calculate the respective probabilities of accident.

In the unlikely event of accidental discharge in a city or town, the first steps would be to secure the area; to decontaminate the liquid material, and to provide first-aid to any individuals who came in contact with the liquid. Supplies are carried in the train to accomplish this. Any alkaline material, such as bleach or quicklime, will rapidly decompose nerve agents. Because the agents have low volatility, there is little vapor hazard; however, people should not be allowed in the downwind vicinity as a matter of precaution.

Question 9. What is the annual cost of our activities in the fields of chemical and biological warfare? What is the cost of munitions and weapons in these fields? Since comparable figures are available for our procurement and research programs in ICBM's, the ABM, Polaris, and similar forces, I assume they can be made available for our CBW program. If they can't, why can't they?

Answer. Total U.S. expenditures in the CB field, including smoke, flame, and incendiary weapons, is $350 million for fiscal year 1969. There is no procurement of lethal chemical agents or of biological agents. Details of expenditures are given in the table below.

CB expenditures—fiscal year 1969

	Million
Procurement:	
Smoke, flame, and incendiary	$139
Riot control munitions	81
Herbicides	5
Defensive equipment	15
Total	240
R.D.T. & E.:	
General and basic R. & D	9
Offensive R. & D	31
Defensive R. & D	30
Test and evaluation	20
Total	90
Operation and maintenance	20

Question 10. Do we have the capability to respond to a massive nationwide gas or biological warfare attack? That is, could we launch a similar and immediate attack against the aggressor? The deterrent effect of our ICBM's is based on the enemy's knowledge that we can and will respond. This has been a policy publicly stated by the Secretary of Defense. Is the same true in the field of chemical and biological warfare?

Answer. The answer to the question, as stated, is no: the United States could not launch an immediate, massive, chemical or biological attack. The United States has the technical capabilities to do this, but it has not been judged necessary or desirable to procure and install the weapon systems for "immediate massive" attack. The carefully controlled inventories are adequate for tactical response against enemy military forces; not for strategic or "nationwide" attack.

Question 11. Do we have a rapid warning system that will alert the public to a chemical or biological attack?

Answer. The United States has developed chemical detection and warning instruments which could provide the components for a national alarm system. They have not been deployed to build such a system. However, as noted above, it is believed that the threat of strategic chemical attack is not great. Warning against biological attack is much more difficult technologically. Recently, there has been success with a prototype instrument which would provide some biological warning capability. R. & D. efforts in this area will be continued.

Question 12. Does the Army use any discretion as to what types of institutions should be encouraged or pressed into accepting funds for work in chemical and biological warfare? Does the Army see any conflict in asking a purely civilian institution, such as the Smithsonian, to do work that might conflict with the institution's activities abroad?

Answer. The Army certainly uses discretion in selection of all of its contractors. The advice of the Smithsonian Institution was sought in identifying a suitable institute to do this work. As a result, they submitted a proposal, which was accepted. As a direct consequence of this work, there have been 45 papers written by Smithsonian scientists and published in the scientific literature. This

has been a remarkably productive scientific investigation brought about by a coincidence of interests in the fauna of the area.

The Smithsonian Institution was never asked to do, nor did they do, any "military" chemical and biological warfare research. It carried out scientific investigations appropriate to its charter and objectives, and published the significant findings in the scientific literature. These results are available for use by the Army, by any other Government agency, or by any nation or scientist wishing to do so.

Question 13. Would the United States or any other major nation be risking its national security by dispensing with chemical and biological weapons altogether, especially in view of their many skills with weapons that have already been used?

Answer. It was pointed out in the discussion of question 1 that CB weapons are, in many military situations, more effective than conventional weapons. Thus, a nation which lacked CB weapons and could not deter or counter their use would have to consider more extreme measures. Unilateral CB disarmament would adversely affect a nation's deterrent capability, it would decrease its response options, and it would ultimately seriously degrade its CB defensive capability. The United States is committed, as President Nixon wrote recently, to "exploring any proposals or ideas that could contribute to sound weapons." The Defense Department is fully in accord with mutual arms control efforts and supports them in every way possible. For example, members of the Department of Defense will join representatives of the State Department and Arms Control and Disarmament Agency in meeting in late April to assist the United Nations Secretary General's group of 14 consultant experts prepare a report to the Secretary General of the U.N. on the characteristics of CB weapons.

Question 14. Isn't it correct, as Dr. Joshua Lederberg has said, that biological weapons are regarded as a tool of dubious value at best?

Answer. It is difficult to answer this question without knowing the context in which Dr. Lederberg stated his conclusion, nor the rationale he used in arriving at it. There are a number of technical uncertainties about the effects of biological weapons, but this does not reduce the vulnerability of the United States to them, nor does it negate the potential hazard they pose. Until such time as it can be proved that they are of little value to any nation, if that is indeed the case, or until reliable mutual arms control agreements are reached, it would be imprudent to dismiss them lightly.

Mr. INDRITZ. On page 3 of your statement, you recommend that a testing safety committee be established, consisting of non-Government members. Do you have any views as to whether other agencies of the Government—such as the Department of Health, Education, and Welfare, with its Food and Drug Administration—which have public health oriented personnel, ought to participate in such a testing safety committee?

Mr. MCCARTHY. Oh, yes, definitely. I certainly do.

Mr. INDRITZ. Did you say they should participate?

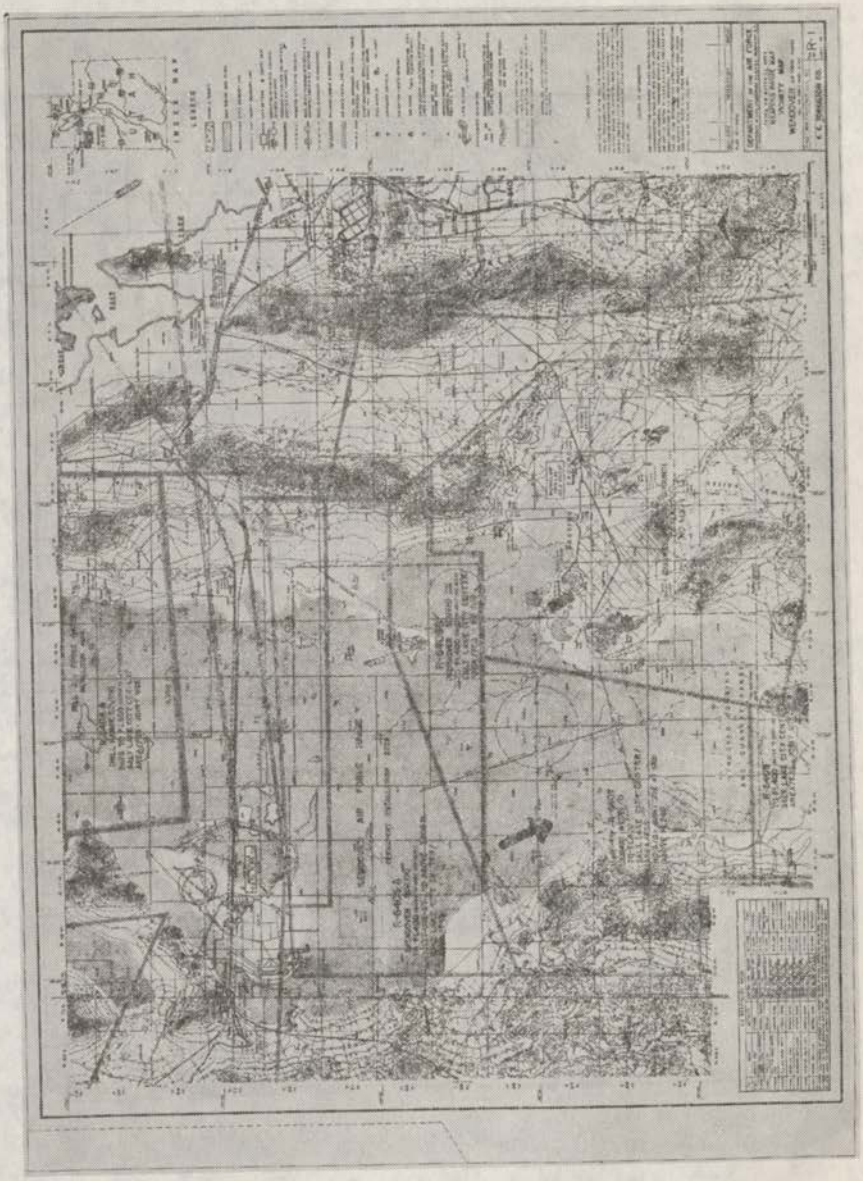
Mr. MCCARTHY. Yes.

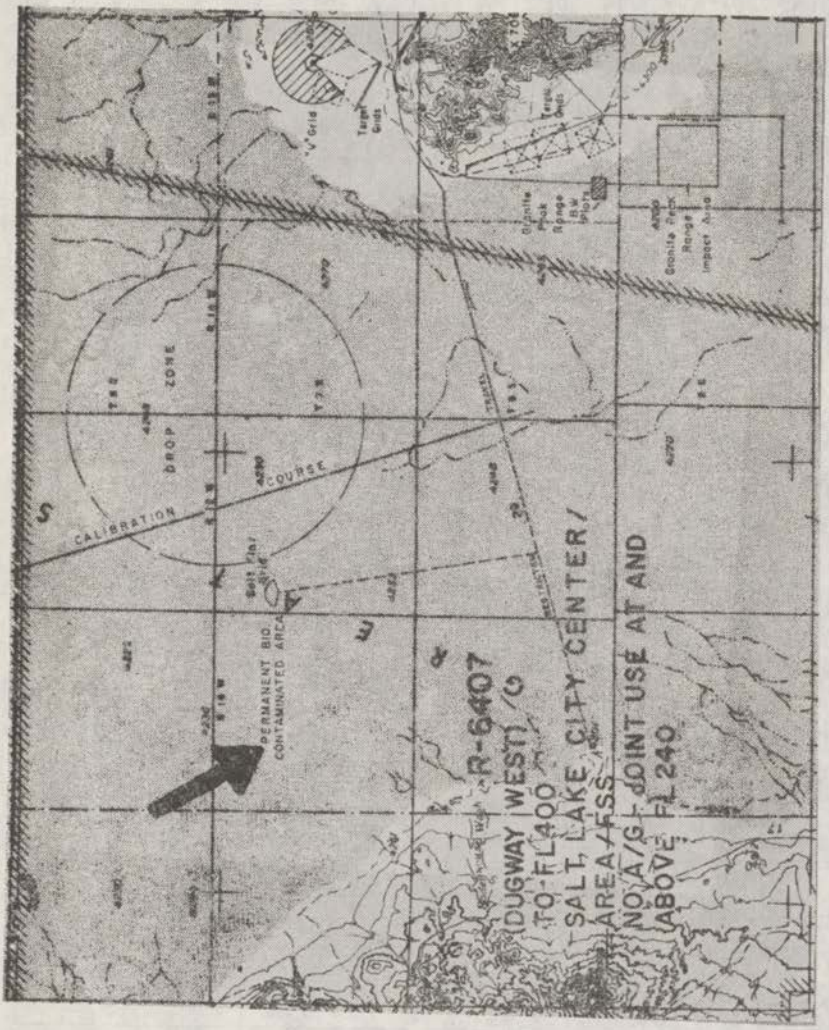
Mr. INDRITZ. You mentioned a map of the Army Air Force's Wendover Air Force Range. Do you have that map here?

Mr. MCCARTHY. Yes, I do, and it is right here on the floor. Could somebody hold that up? Thank you very much.

This is the—you can't read it from there—but all it says is "Permanent Biocontaminated Area."

(Subcommittee note.—The map, U.S. Air Force Vicinity Map of Wendover Air Force Range (July 1967, Tab NR, R–1) and a detail therefrom showing the permanent biocontaminated area appear on pages 19 and 20. The arrows pointing to the words "Permanent Biocontaminated Area" have been added by the subcommittee staff for purposes of clarification.)




R-6407
(DUGWAY WEST) (S)
TO-FL400
SALT LAKE CITY CENTER/
AREA/ASS
NOA/G- JOINT USE AT AND
ABOVE FL240
DROP ZONE
COURSE
CALIBRATION
PERMANENT BIO
CONTAMINATED AREA
Target Grids
Granite Peak Range Impact Area

Mr. INDRITZ. Could you tell us whether that is inside or outside the Dugway Proving Ground boundaries?

Mr. MCCARTHY. Well, I am not certain, really. It looks as though it is in but this is a map of Dugway——

Mr. INDRITZ. I have here the latest topographic map printed by the Army Map Service, Corps of Engineers, in April 1958, entitled: "Tooele, Utah, NK 12–10, Series V502, Edition 1–AMS" which shows the boundaries of Dugway Proving Ground, and the "permanent biocontaminated area" you referred to is approximately 12 to 18 miles west of the west boundary, and outside, of the Dugway Proving Ground.

Mr. MCCARTHY. It is outside it?

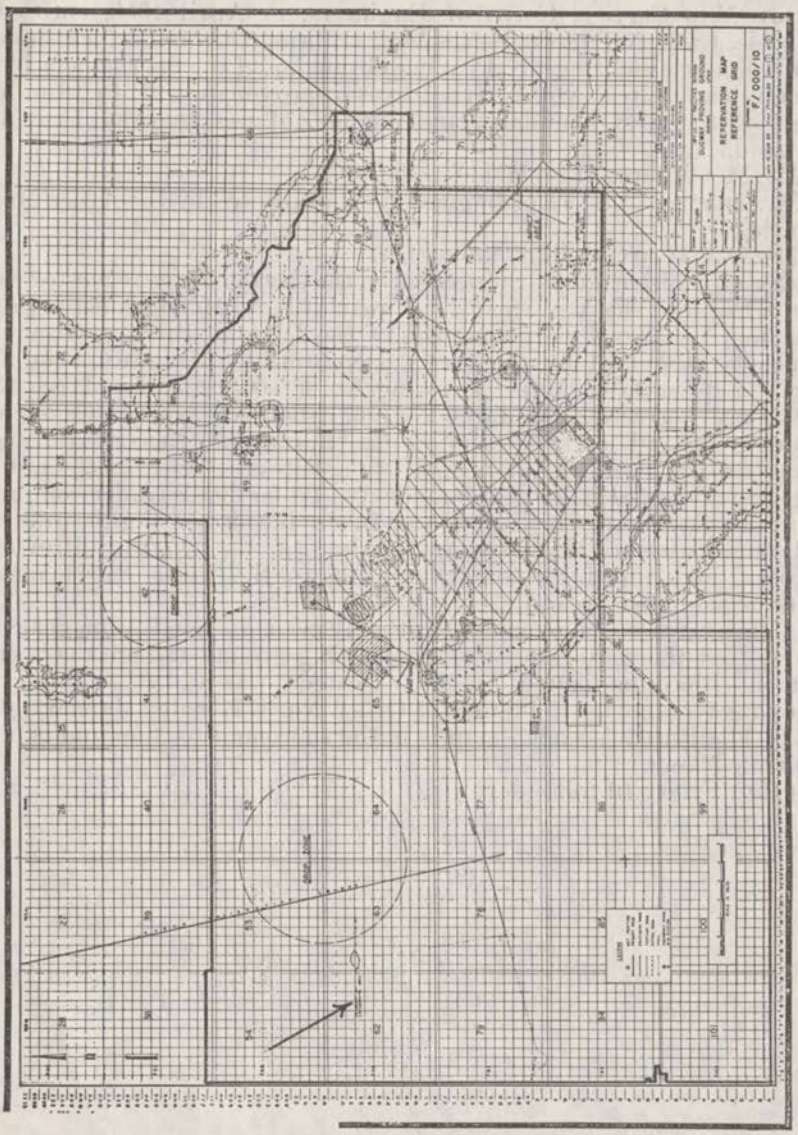
Mr. INDRITZ. Yes, according to this map printed by the Army Map Service.

Mr. MCCARTHY. I didn't know that.

(Subcommittee note.—Subsequently, the subcommittee requested the Department of the Army and the Bureau of Land Management to provide maps showing the boundaries of the Dugway Proving Ground. The map provided by the Army Department ("Dugway Proving Ground Reservation Map," Drawing No. F/000/10, dated March 15, 1965, with corrections to March 27, 1967) shows the boundaries of the proving ground, and also the words "Permanent Biocontaminated Area" in T. 7 S., R. 16 W., S.L.M. Utah. This area is within the proving ground and near its west boundary. (To facilitate reader comprehension of the map, which is reduced in size in this hearing record, the subcommittee staff darkened the outline of the Dugway Proving Ground and added the arrow pointing to the words "Permanent Biocontaminated Area.")

(The sketch map provided by the Bureau of Land Management shows that the western area of the proving ground (where the "permanent Biocontaminated Area" is located) was added to Dugway Proving Ground by Public Land Order No. 1777 dated January 13, 1959. The Bureau's sketch map is in the subcommittee files and is not reprinted here.)

(Map F/000/10 follows:)


REFERENCE MAP
REFERENCE GRID
F/000/10

Mr. INDRITZ. Congressman McCarthy, do you think the Dugway Proving Ground should be closed?

Mr. MCCARTHY. No, I don't. What I have proposed is that we ratify the 1925 protocol. That would simply require us, as a matter of national commitment policy, not to use these weapons first. I have also urged that we support the British resolution now at Geneva, Switzerland, which would be a supplement to the 1925 protocol. This supplement would require that signatory nations give up research into, production of, and possession of, germ warfare agents.

Now if we ratified that, then we would not be able to indulge in activities in the germ warfare area but I am sure that the Army would find other uses for Dugway.

I am not saying we should get completely out of the gas business. I don't think that is realistic, so I am sure they would find use for it. I am not saying it should be closed.

Mr. REUSS. Mr. Carlson, do you have any questions?

Mr. CARLSON. No questions.

Mr. REUSS. Any other questions?

Thank you very much, Congressman McCarthy.

Mr. MCCARTHY. Thank you, Mr. Chairman.

Mr. REUSS. We are pleased to have with us another colleague, Congressman Sherman Lloyd.

STATEMENT OF HON. SHERMAN P. LLOYD, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF UTAH

Mr. LLOYD. I have a prepared text which I believe you have and with your permission I would like to read it to you.

Mr. REUSS. Without objection it will be received. Would you then proceed in any way you care to?

Mr. LLOYD. Thank you.

Mr. Chairman, gentlemen of the subcommittee, Dugway Proving Ground, where tests of chemical and biological warfare have been made and near the area where certain chemical agents recently in the news are stored, is situated in Utah's Second Congressional District which I represent. Consequently, I have maintained a continuing personal interest in the testing of chemical agents and have made inspection visits to the testing and storage areas on two occasions since the incident involving the sheep deaths in 1968. In addition, I have maintained a continuous communication with Federal, State and local officials having a direct or indirect responsibility in protecting public health and disclosing the facts of testing of chemicals and biologicals.

At the outset of this testimony, I wish to make clear my own position. I do not come here as a cheerleader for chemical and biological warfare.

I support—

1. Minimum production, minimum testing, minimum inventory storage, and minimum transportation of the agents consistent with the supportable needs of national defense.
2. Maximum disclosure of production, testing, storage, and transportation and disposal consistent with national security.
3. Maximum security in transportation.

4. Progress toward reliable international agreements controlling, or hopefully eliminating, production and testing of chemical and biological warfare agents.

5. Destruction through detoxification of surplus chemical and biological agents.

6. All reliable evidence as opposed to unreliable opinion and hearsay which may mislead the public.

I have read and heard it said that those of us who live in close proximity to the testing area are more concerned about the economic gains which come through employment provided at Dugway Proving Ground than we are in protecting human health and life.

I would hope the members of this subcommittee would dispose of this gratuitous affront as unworthy of acceptance and would realize that over the years, those who have lived the closest to this testing area have, through necessity, the most concern about health and life, and as a result of that concern, we have been most diligent in making investigation and analysis, and our State administration and statutory public health authorities have maintained the most sensitive posture in remaining constantly alert to the details of testing to protect the health and lives of our people.

The disclosure of testing of chemical agents is not a novel or dramatic development to us. With all citizens we pray for the day when our leaders will be able to say with confidence and assurance that there is no longer a need for research and development in chemical and biological warfare. In the meantime, while we exercise maximum vigilance in determining the details of testing, storage, and transportation procedures, I believe it is necessary for us to seek a balanced judgment in which emotion does not distort fact, in which facts are kept in accurate proportion to their significance, and in which all relevant evidence is considered, rather than merely the most sensational. I am confident this subcommittee will zero in on these reliable facts.

The sheep death incident at Dugway Proving Ground in March 1968 focused national attention on the CBW program. In recent months, it has been the subject of two special programs on national television, plus numerous articles in the Nation's press, and inquiries by Congress.

This spotlight on CBW may lead some to believe that the development of these weapons and the testing of them at Dugway is something new. It is not. Dugway has existed since 1942. The nerve agent suspected of killing the sheep in the unfortunate accident in March of last year was tested literally hundreds of times at Dugway before the sheep incident, beginning with spray tests of nonpersistent nerve agents in 1953. Until the sheep deaths, there had been no offpost incident in about 25 years of chemical testing. It has been recently disclosed in the press that testing has been resumed at Dugway. However, current tests do not involve spray testing of the agent from the aircraft, and are subject to strict safety requirements recommended by the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground.

A comprehensive safety program has been in existence at Dugway for the past 17 years. It is estimated that over 2.4 million man-hours

have been spent in handling, testing, analyzing, and disposing of toxic agents at the base. During this 17-year period, only 17 persons have required treatment for exposure to chemical agents, and none of the cases were considered severe. There has never been a human fatality at Dugway, and given the inherent dangers in the handling of these agents, this is undeniably a remarkable safety record, and one which justifies a certain confidence in the prudence of those who have made this safety record possible. This record does not justify complacency. While I do not in any way suggest the Army is complacent, I nevertheless feel that continued vigilance must be pushed. An area of research justifiable to me would be research which would produce more precise knowledge of the persistency qualities of the chemical agent and more precise knowledge of when and how decomposition of the chemical agent occurs.

I would say the recommendation by Congressman McCarthy that a committee which would be essentially non-Government certainly deserves the close attention of this subcommittee.

I have recently read in the Nation's press that our distinguished colleague, Mr. McCarthy, has been informed that heretofore unpublished fatalities and damages have occurred at the Dugway area in addition to the now familiar case of over 6,000 dead sheep. This information contains the following charges:

1. That 1,700 cows were killed in addition to the sheep, and 100 square miles of rangelands have been contaminated, possibly for 2 or 3 years.

2. That Venezuelan equine encephalitis has been field tested at the Dugway Chemical and Biological Proving Ground in Utah and, further, a number of independent health authorities have expressed their concern that this disease may spread to the animal and human population of the State.

3. That there is a large, permanently contaminated biological testing area within the proving ground which poses hazards to wildlife and, consequently, to humans moving in and out of the area.

I have interrogated authorized officials of the Defense Department as to the validity of these three reports and have received an unequivocal denial in each case. I have inquired of our statutory State public health authorities in Utah. They deny that these reports are true. I have communicated with lawyers for the sheep owners as to the report concerning the death of the cows. They have informed me that the report is without foundation.

(Subsequently, Congressman Lloyd wrote Chairman Reuss, concerning point No. 3 above, as follows:)

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., May 21, 1969.

Hon. HENRY S. REUSS,
Chairman, Subcommittee on Conservation and Natural Resources, Rayburn House Office Building, Washington, D.C.

DEAR HENRY: In my testimony before your subcommittee on May 20, I stated that the Defense Department had given me an unequivocal denial of three reports which I had read concerning chemical and biological warfare agent tests at Dugway Proving Ground. One of the three reports was 3) "That there is a large permanently contaminated biological testing area within the proving ground

which poses hazards to wildlife, and consequently to humans moving in and out of the area."

I was in error in stating that the Defense Department had made an unequivocal denial of that specific report. Actually I am now informed by the Defense Department that such area does exist and disclosure has been made. My previous inquiries to them were in the area of chemical agent testing, and I had not submitted to them the specific report on biological agent testing as contained in my testimony before the committee. I absolve the Defense Department of any effort to mislead and will appreciate your placing this letter in the record in the hearings which you are presently conducting.

Sincerely yours,

SHERMAN P. LLOYD,
Member of Congress.

(The Department of the Army statement of May 20, 1969, to which Congressman Lloyd referred in the above letter, follows:)

In response to a query about a large (10-mile diameter) area at Dugway Proving Ground that is marked as a biologically contaminated area, the Army released the following statement on May 20:

More than 10 years ago the Army placed 100 milliliters (about one teacup full) of a solution containing organisms of a disease common in Utah in a plot of ground, on the proving ground, approximately 100 yards square. There was no possibility of air contamination then, nor is there now. The purpose of this controlled experiment was to determine how long the organism would remain infectious in this dry salt flat area.

The area, which is well within the confines of the proving ground, was selected because the wild mammal population is less than 1 per square mile; the closest human habitation is 20 miles away.

The area was fenced, marked, and monitored to insure that all except scientific personnel would avoid the area. To provide added safety and security, the fence is at least 300 yards beyond the actual test site. It is inaccessible except by special (roller tired) Army vehicles. The test site is still being routinely monitored.

Mr. LLOYD (continuing with prepared statement). It has also been reported to me that on October 17, 1968, the Bureau of Land Management, U.S. Department of the Interior, certified that all of the rangelands involved were now considered safe for livestock grazing. Normal livestock operations began soon thereafter.

Dr. G. D. Carlyle Thompson, who as director of health, Utah State Division of Health, has the primary responsibility for insuring the safety of Utah citizens against activities at Dugway, has stated publicly:

"* * * beginning in 1953, semiannual ecological studies have been made by the University of Utah, both on the Great Salt Lake Desert as well as in the environs of Dugway. None of these studies has identified the dissemination of biological agents used at Dugway. Also, over this period of time, the State health division has shared human blood samples received in its laboratories with the Public Health Service Communicable Disease Laboratory for analysis by them to assure the absence of Dugway agents. While there was never any indication of suspect human disease from Dugway, these checks have been made on a precautionary basis. For while the quantity of any such biological agent actually at Dugway is small, it is realized that wild animals that might become infected on the Dugway site could migrate off the site. There has been no evidence of such wildlife infection."

I have asked Congressman McCarthy to share with me his sources of information so that I may properly represent my constituents, but he has not considered it proper, I presume, to share those sources of

information with me. I, therefore, respectfully request of this subcommittee that the source of this information be disclosed in the national interest and certainly in the interests of my constituency. I presume that this information will be produced at the hearings of this subcommittee. I consider such information to be vital not only to my performance as Congressman of Utah's Second District, but to the national health and safety.

Of course I do not contend there should be blind faith acceptance of everything the military tells us, and congressional inquiry in depth is not only our right, but our duty. At the same time, I think it pertinent to state the Army has made full disclosure to me on every occasion on which I have requested and has readily complied with my requests for briefings and inspection of Dugway facilities. Of course I make no pretense of technical knowledge and am in no position to be judge of scientific issues. As a result of my own inquiry, I am personally convinced, however, that there was no gross negligence on the part of the Army in connection with the sheep deaths, and that proper safeguards are being taken to prevent, if possible within the limits of human frailty, a similar or more tragic incident in the future.

Officials of the Deseret Test Center have taken steps to improve communication with proper State authorities, including the State board of health, the Utah Air Conservation Committee, and representatives of agriculture. I am advised that meetings between Dugway personnel and State officials have occurred since the sheep deaths, and that, on the basis of criteria discussed, some proposed tests were not conducted. There has also been appointed, as recommended by the ad hoc committee, a permanent chemical advisory committee to advise the commanding general of the Deseret Test Center with expert independent opinion concerning the safety of the chemical testing program. This committee, composed of scientists from outside the Defense Department, includes representation by the Utah State Director of Health. The Governor of the State and the Utah State Director of Health are also given regular briefings on all planned testing at Dugway. In addition, other steps to increase safety in the area have been implemented, which I will leave to military experts to describe in depth.

It has been my policy to encourage the Army to make greater public disclosure on activities at Dugway, consistent with national security. Some of the secrecy surrounding CBW is obviously necessary, but some is obviously excessive and not essential to national defense. The public, especially those who live in close proximity to installations conducting CBW research, has every right to general information as to what is going on, and what dangers exist.

In conclusion, between an information void and alarm-producing exaggerations, there should be an informed vigilance and a reliable balance of evidence upon which the people can depend. It is my hope that the hearings conducted by this subcommittee will disclose additional means whereby this balance may be achieved.

I would like to thank you and the committee for allowing me to make this presentation.

Mr. REUSS. Thank you very much.

You spoke in your testimony of the setting up recently—I am referring to page 5 of your testimony—of a permanent chemical advisory committee to advise the commanding general of Desert Test Center with expert, independent opinion concerning the safety of the chemical testing program.

Can you tell us who the chairman of that committee is?

Mr. LLOYD. The chairman—this is principally Government scientists outside the military department. The chairman is Dr. Jake Nolen, 1002 Overbrook Road, Wilmington, Del.

Mr. REUSS. That is the home of the E. I. du Pont de Nemours chemical company?

Mr. LLOYD. That is right. I have no information as to whether Dr. Nolen is associated with that company.

Mr. REUSS. Is it not a fact that he has been an official of E. I. du Pont de Nemours chemical company for many years now?

Mr. LLOYD. That information is not in my possession, Mr. Chairman. I assume that you have that information and as I have suggested before, I think that the establishment of this permanent committee is a matter to which your subcommittee should pay the closest attention.

Mr. REUSS. If it did turn out that the chairman of the permanent chemical advisory committee was employed by a chemical company, would that affect your judgment that the advisory committee is likely to provide the Nation with "expert, independent opinion?"

Mr. LLOYD. I would say, Mr. Chairman, I would assume that he would place the health and safety of the country, give that higher priority than profit to his own company. Some may disagree with me. It is a matter of opinion.

In my own mind I would not question his integrity.

Mr. REUSS. Congressman Lloyd, as you have testified, you have seen it as your duty to become thoroughly familiar with the facts surrounding the March 13, 1968, sheep-kill in the Dugway area.

In your judgment, is it likely that the sheep-kill was due to U.S. Army testing of VX nerve gas?

Mr. LLOYD. I think it is, and there are statements made that the Army—I don't know whether the statement was that they originally denied it or whether they failed to admit it. There has been a congressionally approved claim to the Anschutz Land Co. of $376,385 which has been paid for death of the sheep. Another claim lodged of nearly $200,000 for damage to the land.

In my opinion, after inquiry of the Army, I saw no effort to cover up but since the matter involved financial liability I think that they were exercising due prudence in making very sure that the evidence justified whatever admissions they would make. I was there soon after the report of the sheep deaths and there was not an effort made at that time by them to deny to me. Neither, at the same time, did they feel their tests, made in good faith in my opinion, justified that they admit. Subsequent tests determined beyond a reasonable doubt that the test was the cause of the deaths and that is what I believe was the cause.

Mr. REUSS. Congressman McCarthy just testified that shortly after the March 13, 1968, incident Dugway Public Information Officer Tom Donnelly denied that Dugway was running any tests.

Congressman McCarthy also testified that on March 24, 1968, another spokesman at Dugway denied any connection between Dugway's activities and the sheep death.

You don't have any knowledge whether in fact those statements were made by Dugway officials?

Mr. LLOYD. I asked those questions of the Army and let me tell you what they told me. We are in the field of hearsay. They have a biological section and a chemical section. Like many divisions within our great companies, sometimes one hand is not entirely familiar with what the other hand is doing.

The call was made to the biological section. A routine call. "Were you conducting tests yesterday?" They said, "No." But I think that there was never a denial by the chemical division, chemical warfare, that chemical tests were made. I don't think there was a denial to persons cleared for classified information.

Mr. REUSS. If there was a denial by the Dugway public information officer, Tom Donnelly, that VX tests had been conducted, that denial would have been false; would it not? To your knowledge?

Mr. LLOYD. Well, I think—my own opinion was that there was no deliberate effort to lie. I think there was some confusion.

Mr. REUSS. That wasn't my question. My question was if Dugway Public Information Officer Tom Donnelly did deny the Army had been conducting VX tests at Dugway, that denial would have been false, would it not?

Mr. LLOYD. That is true; there is no question but that the tests were made.

Mr. REUSS. You referred in your testimony to certain allegations made by Congressman McCarthy. This is on page 3 of your testimony. One such allegation which you included is that "A large permanently contaminated biological testing area within the proving ground" exists. You say you have interrogated authorized officials of the Defense Department as to the validity of these reports and have received an unequivocal denial in each case.

Did the Defense Department officials deny that a permanently contaminated biological testing area exists?

Mr. LLOYD. That is my understanding. I can check that for the record.

Mr. REUSS. I would like to have the clerk show Congressman Lloyd the Department of Defense Air Force map of the Dugway Proving Ground because Congressman Lloyd has asked of this subcommittee that the source of Congressman McCarthy's information be disclosed. It seems to me that, as to this allegation, it is the Defense Department's own admission as contained in the map.

Mr. LLOYD. Has the Army notified that that is permanently contaminated?

Mr. REUSS. Well, this is a map—incidentally, I think we should have this in the record and, without objection it will be admitted. The map is described as "Department of the Air Force Vicinity Weapons Range Map," dated July 1967, and it shows, in the Dugway area, an area called "Permanent Bio Contaminated Area."

It also shows another area caleld "Granite Peak Range BW Plots." I assume BW means biological warfare.

Doesn't that indicate that Congressman McCarthy was not talking through his hat?

(The map referred to, and a detail therefrom showing the "Permanent Bio Contaminated Area," appear on pp. 19 and 20.)

Mr. LLOYD. I didn't say that he was. He did say it was within the proving ground and it is not within the proving ground.

Mr. REUSS. I am glad you didn't, because it seems to me it would be worse to have a biocontaminated area outside the proving ground than to have one inside the proving ground.

Mr. LLOYD. It may well be. I am not here as an apologist for the Army.

Mr. REUSS. Would it not appear as if the Defense Department officials to whom you talked lied to you?

Mr. LLOYD. No.

Mr. REUSS. Why not? You just said that they denied there was a contaminated biological testing area.

Mr. LLOYD. Within the proving ground.

Mr. REUSS. But quite seriously, don't you think honorable men would have had to answer your question by saying "No, we don't have such an area within the proving ground, but right outside there is one"?

Mr. LLOYD. I understand that they are going to—they have been called to testify before your subcommittee and I would leave that to them.

Mr. REUSS. We will give them a chance. Your testimony is—even though you have now seen the Department of Defense Air Force map showing a contaminated biological testing area of a permanent nature, either in, or very close to, the Dugway Proving Ground—that authorized officials of the Defense Department didn't lie to you when they denied any knowledge of this?

Mr. LLOYD. I am convinced within myself they made no effort either to lie or deliberately mislead. When they denied there was a contaminated area within the proving ground they were undoubtedly replying to my specific inquiry.

Mr. REUSS. A second point made by Congressman McCarthy which you raised is that Venezuelan equine encephalitis, VEE, has been field-tested at the Dugway Proving Ground in Utah, and there, too, you say that authorized officials of the Defense Department unequivocably deny this.

Is there Venezuelan equine encephalitis at the Dugway Proving Ground area?

Mr. LLOYD. I would have to rely on hearsay. I think that perhaps there is but I am not an authority on that. I think there are others who may be.

Mr. REUSS. Has the Army tested VEE at a place other than in the field, to wit, in the laboratory or in test chambers?

Mr. LLOYD. I have no idea. They have told me there has been no field testing.

Mr. REUSS. They didn't go on to say whether or not there had been testing other than field testing.

Mr. LLOYD. I didn't inquire. The charge had been made and I merely asked them about the validity of the charge, as to whether there

had been field testing. I think antibodies against this encephalitis had been found in some of the rodents in the area.

Mr. REUSS. The third charge by Congressman McCarthy on which you comment is that 1,700 cows, in addition to 6,400 sheep, were killed. You state that this, too, has been categorically denied by the Defense Department, and you also say "I have communicated with lawyers for the sheep owners as to the report concerning the death of the cows. They have informed me the report is without foundation."

Who were the lawyers for the sheep owners?

Mr. LLOYD. That might be an unfortunate wording. I asked Mr. Marvin Bertoch, one of the counsel for the Anschutz Land Co., to whom was paid the claim for the loss of the sheep, if his client or within his inquiry during the time of presenting the claim if there had been any dead cows and his reply was no.

Mr. REUSS. Mr. Bertoch was speaking for his client, the Anschutz Land Co.?

Mr. LLOYD. He was speaking for himself but he was one of the attorneys for the Anschutz Land Co.

Mr. REUSS. If the 1,700 allegedly dead cows had been owned by anybody else in Utah other than the Anchutz Land Co., this lawyer's answer would not have covered that, would it?

Mr. LLOYD. No, but I understand that there are people from the Utah State Health Department here who may give you further enlightenment on that.

Mr. REUSS. U.S. 40——

Mr. LLOYD. May I interject here?

I am not saying that these reports are false. I say that these reports are of such great consequence that I would hope your subcommittee would by all means reveal the nature of the information so that I can share it.

Mr. REUSS. We certainly intend to try to get at the facts and whatever we find out we will, of course, share with you, Congressman.

U.S. Highway 40 runs east and west about 30 miles north of the Dugway Proving Grounds; is that correct?

Mr. LLOYD. Approximately.

Mr. REUSS. Is that also Interstate Highway 80?

Mr. LLOYD. Yes. It will be, completed.

Mr. REUSS. Am I right in my understanding that it is the principal east-west highway between Chicago and Salt Lake City and the San Francisco Bay area?

Mr. LLOYD. Yes.

Mr. REUSS. Have you any idea how many people use that highway weekly?

Mr. LLOYD. I have no idea.

Mr. REUSS. But it is widely traveled.

Mr. LLOYD. Oh, yes.

Mr. REUSS. Thank you.

Mr. Vander Jagt?

Mr. VANDER JAGT. Thank you, Mr. Chairman.

I would like to thank Congressman Lloyd for appearing before this subcommittee and giving us the benefit of his testimony. I think his statement reflects a great deal of knowledge and a long time interest in the problems and close monitoring of the situation.

You did make the statement, Congressman Lloyd, that, on the basis of your knowledge of the incident at Dugway which led to the killing of the more than 6,000 sheep, you were satisfied there was no gross negligence on the part of the Army. Were you able to formulate an opinion as to what did go wrong and why?

Mr. LLOYD. Well, Mr. Vander Jagt, that would be a layman's opinion. I am satisfied that the death of the sheep was caused by a series of circumstances involving the test of the nerve agent.

Now as to the scientific chain of events, including the meteorological, the matter of the release of the agent, all of the rest, it is in the scientific realm and I don't think my opinion would be the best evidence on this.

Mr. VANDER JAGT. You did indicate in your statement that we are dealing in an area where much is unknown. In your statement you called for more precise information such as the permanency of these chemicals and the like. Would you have an opinion as to who should take the initiative to get this more precise information that I would assume would lead to more adequate safeguards?

Mr. LLOYD. Well, I don't know whether it makes any difference whether within the scientific community this should be Government or non-Government and I am certainly not prepared to say there hasn't been close attention to this research into persistency; but I am concerned, for example, when the agent, after a test, goes below the soil, does it decompose actually, and if so, in what types of soil will it be completely decomposed; are there other types of soils in which there would not be sufficient decomposition to prevent it from seeping into underground water supplies?

I don't think we can have too much information about the persistency qualities of this agent and, as a citizen who lives there, that is a matter with which I feel we must be particularly concerned.

Mr. VANDER JAGT. As a citizen who lives there, you have a great concern, I would assume, about the health aspects of the situation?

Mr. LLOYD. Well, we feel that our concern is greater than those who live outside of the area.

Mr. VANDER JAGT. Incidentally, on this list of charges or statements that have been made, it is my understanding that your reason for mentioning them was that you were urging this subcommittee to get at the source of the information; is that correct?

Mr. LLOYD. It is very strategic. If this information should prove valid, then we have a much larger problem than I suspected. This is the type of information that has been reported in the national press and the national news media and so I am very anxious to determine its validity. I make no charges that it is invalid but it is of overriding significance, in my view, that its authenticity be documented.

Mr. VANDER JAGT. And your purpose in mentioning it was to urge us to get at the source of the information so that it can be evaluated; is that correct?

Mr. LLOYD. That is right.

Mr. VANDER JAGT. Now on this map I note that there is marked in the Dugway Proving Ground area an Indian reservation, Skull Valley Indian Reservation. Do you know: Is that inhabited and if so, by how

many people; and if there are people, are precautions taken to safeguard them?

Mr. LLOYD. Both the State Board of Health and the Bureau of Indian Affairs and the people at Dugway Proving Ground themselves take the most complete precautionary measures not only with the Indians but with all human beings. They make a very careful close count of identification and location of all of the human beings within the area.

Mr. VANDER JAGT. Thank you, Mr. Chairman.

Mr. REUSS. Mr. Gude?

Mr. GUDE. Thank you for your statement, Congressman Lloyd.

Would it be the thrust of your conclusion that, until all is known to necessarily protect life and health of the individuals who could come in contact in any way with these agents, you would oppose the testing in the atmosphere—until the facts and circumstances surrounding the use of these agents in testing——

Mr. LLOYD. I can't speak for my constituency. I can speak only as an individual citizen. As far as I am concerned, I have confidence that the precautions are adequate and that the continuation of testing would not disturb me as a citizen.

Mr. GUDE. What I am saying, for example, is: you mention in connection with the reaction of either biological agents with the soil and their contamination with ground water, that until the facts have been determined as to whether there was danger of contamination of, say, water supplies or air in which we endanger lives, you would oppose the testing or——

Mr. LLOYD. No; I would not. The Army and other authorities have conducted great research into the qualities of persistency and I think you will be able to interpret them. I think my testimony would be that we can't have too much information about that. That would give me even greater assurance, I would put it that way. But in the meantime I have no personal apprehension as a resident of the area.

Mr. GUDE. Yes. What I am saying is that if there is an area in doubt, you will oppose testing, and you are assured the service and the various authorities have checked out all probabilities, but if there were an area of doubt you would go to the side of not testing until information had been——

Mr. LLOYD. I think if the public health authorities of Utah were to say we can't guarantee to you that this water is free of the agent, then I would not be in favor of testing, but they make no such statements.

Mr. GUDE. Thank you.

Mr. REUSS. Congressman Lloyd, have you asked the officials of Dugway to keep you rather fully informed of testing activities?

Mr. LLOYD. Yes; although their primary responsibility is to the State health authorities and to the Governor, who are there on the spot, and I am not. I have asked them for all reasonable information and continual communication and they have been most cooperative in every way.

I don't assume any primary responsibility in the matter, though. That is up to the State authorities.

Mr. REUSS. In your testimony you said that testing of VX has been

resumed at Dugway following the March 13, 1968, incident. When was it resumed and on what dates have tests been conducted?

Mr. LLOYD. It was approximately a month ago, I think. I am now informed it was in December.

Mr. REUSS. Of 1968?

Mr. LLOYD. That is right.

Mr. REUSS. And has it been going on continuously since December 1968?

Mr. LLOYD. Yes. That is my understanding.

Mr. REUSS. And it is going on today as far as you know?

Mr. LLOYD. That is my understanding. This is not sprayed out of aircraft, however. These are from towers.

Mr. REUSS. What about artillery shells?

Mr. LLOYD. I am not sure about that. I don't think so. I think it is merely from towers. But there will be people here, I understand, who will have that information.

Mr. REUSS. Mr. Carlson, do you have any questions?

Mr. CARLSON. With reference to this Air Force map, I was wondering about the use of the word "permanent." Could it have some other connotation than as a modifier of "contaminated?" It doesn't say "permanently biocontaminated." It says "permanent biocontaminated area." I note at another point on the map it says "Air Force range. Permanent installation."

Mr. LLOYD. I can't give you enlightenment on that. I have not studied the map.

Mr. REUSS. Mr. Counsel?

Mr. INDRITZ. Congressman Lloyd, what is the total of the economic or monetary benefits that military installations, operation and payroll bring into Utah?

Mr. LLOYD. Well, I can't tell you the total but the Deseret Center, which is Dugway, has a payroll of 1,500 in Utah employed with an annual payroll of $13,606,000. Now as to the total I will be glad to supply that for the record. I don't have it totaled up. I have it individually broken down. It is very substantial.

Mr. INDRITZ. Was the total you just stated only for the Dugway operation?

Mr. LLOYD. The Deseret operation, which includes Dugway.

Mr. INDRITZ. Can you supply the total of the economic or monetary benefits of all military operations and payroll in Utah?

Mr. LLOYD. Yes.

(Subsequently, the following data were submitted by Congressman Lloyd. Additional information, supplied by the Department of the Army, follows Congressman Lloyd's memorandum.)

CONGRESS OF THE UNITED STATES,
HOUSE OF REPRESENTATIVES,
Washington, D.C., May 26, 1969.

MEMORANDUM

To: The Honorable Henry S. Reuss, Chairman, Subcommittee on Conservation and Natural Resources.
Subject: Military payroll—State of Utah.

I was asked during hearings last week on chemical and biological testing at Dugway Proving Ground, to submit for the record the total military payroll in Utah. The information for fiscal 1967, the latest figures available, is as follows:

	Millions
Total nonagricultural payroll	$1,770
Total Defense payroll	231
Military personnel	28
Civilian personnel	203

Source: Statistical abstract of the United States, 1968; Utah Economic and Business Review, March 1969.

SHERMAN P. LLOYD,
Member of Congress.

DEPARTMENT OF DEFENSE PRIME CONTRACT AWARDS OF $10,000 OR MORE IN UTAH, JULY 1968 TO MARCH 1969

[In thousands of dollars]

Program	Total value	Research and development[1]	Educational institutions[2]
Total	113,882	13,872	2,875
Airframes and related assemblies	629		
Other aircraft equipment and supplies	1,168		
Missile and space systems	48,328	9,673	19
Ships	37		
Combat vehicles	70		
Noncombat vehicles	568		
Weapons	772	215	
Ammunition	4,379	415	19
Electronics and communication equipment	18,835	410	286
Petroleum	9,915		
Other fuels and lubricants	235		
Textiles, clothing, and equipage	178		
Building supplies	6,717		
Subsistence	2,392		
Production equipment	446	13	
Construction	4,809		
Construction equipment	982		
Medical and dental supplies	260		
Photographic equipment and supplies	255		
Materials handling equipment	63		
All other supplies and equipment	6,891	1,645	1,575
Services	5,953	1,501	976

[1] Included in State totals.
[2] Included in R. & D. and State totals.

DEPARTMENT OF DEFENSE, FISCAL YEAR 1969, ESTIMATED PAY

STATE OF UTAH

[In thousands of dollars]

	Total	Civilian	Military	Reserve and National Guard	Retired
Army	75,946	59,130	4,728	8,906	3,184
Navy	3,998	1,214	948	492	1,340
Air Force	182,014	150,038	24,096	4,180	3,70
Defense Supply Agency	26,490	26,490			
Defense Contract Audit Agency	278	278			
Total	288,726	237,150	29,772	13,578	8,226

Mr. LLOYD. I think with reference to that I also made a comment regarding any assumptions which would be taken. I made my own comment on the record as to the assumptions which would be taken from that figure.

Mr. REUSS. Thank you very much, Mr. Lloyd. We are most grateful for your usual excellent testimony.

We will now hear from Dr. Gustave L. Davis, pathologist, Jewish Hospital of St. Louis, instructor in pathology, School of Medicine, Washington University, St. Louis.

STATEMENT OF GUSTAVE L. DAVIS, M.D., ASSISTANT PATHOLOGIST, JEWISH HOSPITAL OF ST. LOUIS; INSTRUCTOR IN PATHOLOGY, SCHOOL OF MEDICINE, WASHINGTON UNIVERSITY, ST. LOUIS, MO.; CHAIRMAN, CHEMICAL AND BIOLOGICAL WARFARE SUBCOMMITTEE, COMMITTEE FOR ENVIRONMENTAL INFORMATION, WASHINGTON UNIVERSITY, ST. LOUIS; ON BEHALF OF THE COMMITTEE FOR ENVIRONMENTAL INFORMATION

Dr. DAVIS. Thank you, Mr. Chairman.

It is a privilege to appear before this subcommittee on behalf of the Committee for Environmental Information, St. Louis.

Mr. REUSS. Dr. Davis, I believe you have a prepared statement; do you?

Dr. DAVIS. Yes, sir; we have submitted in testimony a written statement which is rather lengthy and in addition we have submitted two copies of our publication, one on chemical and biological warfare and one which includes an article entitled "The Wind From Dugway."

In addition there is a study by Dr. Pallmann, coauthor of "The Wind From Dugway," which has been submitted and which deals with the meteorology.

Mr. REUSS. Without objection the testimony of Dr. Davis and the three annexes referred to will be made part of the record. What portion of the annexes should be printed is something the subcommittee can determine later.

(Subcommittee note.—"The Wind From Dugway" and "Chemical Weapons—What They Are, What They Do" are reprinted in the appendix of this hearing record, on pp. 209 and p. 229, respectively. Dr. Pallmann's study. "Study of Weather Development and Meteorological Meso-Scale Conditions in the Area Southwest of Salt Lake City, Utah, During March 10–14, 1968," is in the subcommittee files.)

Mr. REUSS. Would you now proceed, Dr. Davis. I know your statement is some 20 pages long. I would hope you could hit the high points.

(Dr. Davis' prepared statement follows:)

PREPARED STATEMENT OF GUSTAVE L. DAVIS, M.D., ASSISTANT PATHOLOGIST, JEWISH HOSPITAL OF ST. LOUIS; INSTRUCTOR IN PATHOLOGY, SCHOOL OF MEDICINE, WASHINGTON UNIVERSITY, ST. LOUIS; CHAIRMAN, CHEMICAL AND BIOLOGICAL WARFARE SUBCOMMITTEE, COMMITTEE FOR ENVIRONMENTAL INFORMATION, WASHINGTON UNIVERSITY, ST. LOUIS; ON BEHALF OF THE COMMITTEE FOR ENVIRONMENTAL INFORMATION

Mr. Chairman, it is a privilege to appear before this subcommittee on behalf of the Committee for Environmental Information, St. Louis (CEI). CEI provides scientific information relevant to political and social issues, without bias or prejudgment, in the belief that the dissemination of such information is necessary if citizens are to participate in a democratic society in a technological age. We publish "Environment" (formerly "Scientist and Citizen") containing information about the effects on the environment of various technologies, the peaceful and military uses of nuclear energy, and chemical and biological agents.

In 1967 CEI published a special issue on chemical and biological warfare. (4)* In January 1969, we published an article, "The Wind from Dugway" (2), which was concerned with the escape of a chemical warfare agent in Utah in the spring of 1968. I would like to submit the article by Drs. Sidel and Goldwyn in the CBW issue and the Dugway article for the record. My remarks will be based on information in these articles as well as other material.

*See end of article for references.

Mr. Chairman, you asked that we address ourselves to certain specific questions. I will repeat the questions and then answer them to the best of our ability, although in many cases the information you would like to have is apparently not known or remains classified.

The fact that this information is not available is a deadly serious matter. If Congress and the people are to make the vital decisions about the manufacture, testing and use of these agents—decisions which may determine the life or death of hundreds of thousands of our people—they must have the facts. If scientists outside the military are to contribute their expertise to the resolution of these problems, we must have the facts.

There was testimony before Congress as long ago as 1960 advocating increases in our chemical and biological warfare effort, but the hazards of testing, transportation and disposal were not presented. Since that time our stockpiles have vastly increased, but many of the necessary facts are still not available. This country has had previous unhappy experience with leaving questions of this nature to the military, and to scientists consulted by the military in secret.

The dangers of atmospheric testing of nuclear weapons were also secret during the early years of that testing. Scientific discussion was limited to small, secret committees. It was not until the whole subject was brought out into the open, and classified information released that the errors of the military and their scientific consultants could be corrected, and that Congress and the public could play their proper role in decisionmaking.

You asked: What are the hazards to human beings and animals of *breathing aerosols or dust particles* containing or contaminated by highly toxic chemicals, with special reference to the tiny quantities of VX which can produce physiological effects per unit of animal weight?

The highly toxic chemicals referred to are forms of organophosphates—the nerve gases, the pesticides and the antiparasite drugs act in the body in the same way. (*28, 32*) They block cholinesterase, producing a severe central nervous system disorder. Certain nerve impulses are transmitted by a natural chemical, acetylcholine; after transmitting the impulse to muscle or organs, the acetylcholine is destroyed by another natural substance called cholinesterase. If the action of the cholinesterase is blocked by one of the organophosphate poisons, the acetylcholine continues to send its now inappropriate signals throughout the body, and the functions of the brain, the digestive system, and the respiratory system—all the body's functions are rapidly thrown into a state of disorder. To determine whether an organophosphate poison has been taken into the body, blood cholinesterase is measured. If it is found to be below normal, this is an indication of organophosphate exposure. However, it is not only the blood cholinesterase that is affected by these poisons, but the cholinesterase throughout the body, at junctions of nerves and muscles.

The specific toxicity of VX and similar nerve gases are not available in the open literature. It was clear from the recommendations made by the Report of the Interagency Ad Hoc Committee for Review of Testing Safety at Dugway Proving Ground that there were also many facts about its toxicity to people, to animals and to plants that were not known to the Army. If the toxicity were well understood it would not have been necessary for the ad hoc committee to recommend that:

"* * * Determination or estimation be made of the toxic and lethal activities of single and repeated doses of the chemical by intravenous, intramuscular, subcutaneous, oral, inhalation and cutaneous injection or application, on humans or animals * * *."

as well as other laboratory and ecological studies. Whether these studies have now been done and the answers found is not known to us.

The toxicity to a few animal species was determined, and was given in the report of the National Communicable Disease Center. For example, the LD–50 (the dose which would kill half of the subjects exposed) when absorbed through the skin is 1.2 milligrams for 40 kilogram sheep. If men were equally sensitive, an 80 kilogram man (about 180 pounds) could be killed by 2.4 milligrams. That is about 84 millionths of an ounce. However, sheep may be much more susceptible to this nerve agent than people.

Another way to approximate the lethality of VX is to compare it with the Swedish "F" agent, which has been reported to be five times as toxic as Soman (*26*). Soman is one of the "G" agents, an early nerve gas, now outmoded by the V agents. The LD–50 of Soman has been reported to be 1,250 milligrams for a man (*26*). F gas would therefore be lethal at a dose of 250 milligrams.

It is possible to determine the lethal dose (LD–50) of a VX-like compound in animals quite specifically. An LD–50 can then be *estimated* for people, but there is no way of determining exactly how much it will take to kill a person except by exposing some individuals to a series of doses under controlled conditions. Since such an experiment would result in the death of some of the subjects, it cannot be carried out.

What is the relative toxicity and persistence of VX as compared to other organophosphate compounds, for example, the insecticide, parathion?

The pesticide parathion, an organophosphate poison, has been reported to be nontoxic when applied to the skin in large amounts at 2 percent concentrations (*17, 18*).

When either of these organophosphates is inhaled (parathion or VX), it acts more readily and at smaller doses than when absorbed through the skin, but the specific toxicity is not known for either agent by the respiratory route. The average lethal dose of Sarin, another G agent, when inhaled, is 1 milligram (*24*). VX is more toxic than Sarin.

In regard to the persistence of VX, information is not available. Apparently the Army, at the time of the sheep-kill incident, was also not in possession of all the facts, as the ad hoc committee recommended that the toxicity and persistence of residues of the compound on test sites and other areas be determined. Parathion is persistent for more than 125 days at 25° C. (*14*). Recommendations have been made that orchards sprayed with 8 ounces of parathion per acre be closed for 21 days. VX is classified as "persistent" but just how persistent is not known to us. The persistence, volatility, and particle size can be varied by the vehicle or solvent the gases are carried in, and the means of distribution. The agents can also be mixed with other materials which may increase their toxic effect and which may make treatment more difficult. Such solvents as dimethylsulfoxide (DMSA) may also be used to increase their penetration through the skin (*26*).

There is considerable variation among species in sensitivity to the agents. Published data concerning the effect of organophosphate pesticides—on various animals show that different species, even different breeds of the same species, have differing susceptibilities to organophosphates. Brahman cattle appear to be much more susceptible to the action of certain organophosphates used in spraying and for treatment of parasites than other breeds of cattle (*25*). Sheep are highly sensitive to an organophosphate (dimethoate) which is used against parasites (*23*). It is interesting to note that the longer the shelf age of dimethoate, the more toxic it becomes to sheep.

It would be interesting to know whether the same applies to the related nerve gases. For example, the "G" agents that had been stored for 20 years and were to be dumped in the ocean—has their toxicity been increasing during their 20 years on the shelf?

Is the recommendation of the interagency committee that restricted open-air testing of persistent, lethal agents be permitted, consistent with its medical recommendation that a mass casualty and medical evacuation procedure be developed and tested annually?

The kind of precautions that are recommended in the agricultural use of organophosphates and the medical facilities available for their support appear to have been in effect on base at the Dugway Proving Ground. The report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground approved the precautions and medical care taken there. At that time, the protection of the civilian population on and off the base was sharply questioned. Some people off the base are within 30 miles of the target areas.

Open-air testing of nerve gases has recently been resumed. At the time the ad hoc committee's report was released, the Army announced that all its recommendations had been adopted. Before discussing possible inconsistencies in the committee's recommendations, we would like to suggest that this subcommittee inquire particularly into just what safety measures proposed by the committee have been adopted, and how they are being put into effect.

What changes have been made in the control mechanisms of the high-performance aircraft used for tests, to insure that only the desired, measured quantity of the agent is released? What additional radar and radio control has been instituted? What limitations have been established on the total quantity to be released? What further meteorological capability has been added between the

sheep-kill incident and resumption of testing to insure that the following recommendation can be met: "Confidence in the weather forecast shall be high; there must be past experience demonstrating the reliability of predictions from similar weather situations."

Has the recommended toxicological research been completed? Have determinations or estimations been made of the toxic and lethal activities of single and repeated doses of the chemical by intravenous, intramuscular, subcutaneous, oral, inhalation, and cutaneous injection or application, on humans or animals, including laboratory species, economically important species in the vicinity of the proving ground, and representative wild species, living on or near the proving ground, of both sexes and representative age brackets, and on pregnant females?

Has the toxicity and persistence of residues of the compound on test sites and other areas of the proving ground been determined?

Have estimates been made of the additional insult due to the chemical in foraging animals that have partaken already of known poisonous forage plants indigenous to the area of the testing facility?

Have determinations been made of the presence and persistence of toxic residues of each of the chemical agents tested at Dugway upon indigenous vegetation and of their absorption by the soil by indigenous plants and whether the plant decreases or increases the toxicity of the chemical after its absorption into the plant?

Have determinations been made of the presence and persistence of the compound in soil and in water supplies, including snow, at all seasons of the year in the neighborhood of the test site?

If all these things have been done, to what extent is each based on determinations, with adequate data, and to what extent on estimates, and when estimates were used, how were they arrived at? How much of this information is available to the scientific community or the Congess? Secrecy is no protection to populations or environments at risk.

What changes have been made in the monitoring procedure for chemical agents to detect the presence of or verify the absence of chemical agents by both immediate responsive methods and by ecological monitoring?

Does the Deseret Test Center now exchange technical information with the Utah State Departments of Health and Agriculture and other appropriate State agencies as it relates to chemical test planning and offpost monitoring and safety? What kinds of technical information are made available to these agencies?

Has the standby emergency plan of action been worked out, and measures taken to insure that it can be put into effect promptly if needed? Does this include the recommended mass casualty evacuation procedure? Was the first of the recommended annual exercises to test the mass casualty and medical evacuation procedure held prior to resumption of field testing?

Has a permanent interagency technical safety committee advisory to the commanding general of the Deseret Test Center been established? What is its membership?

In reviewing the ad hoc committee report, we suggested three additional types of monitoring (*2*); the use of treated cards which are sensitive either to the agent itself or to the oily carrier; use of dye, with a specific color being limited to a specific agent, and environmental sampling for the presence of the dye immediately after every test; and the addition of fluorescent particles to the oil carrier—vegetation can then be quickly checked for the presence of the particles with a portable detetor. Devices are being developed and may well be available which will both detect and protect individuals in the field. In 1967, three portable, easily carried badge-type detectors were reported in the journal, "Military Medicine" (*33*). Are any of these in use at Dugway?

The Army has also announced a new portable, automatic alarm for detecting the presence of nerve gas (Environment, April 1969, p. S–4). Is this being used on the periphery of the proving ground?

The necessary detection equipment should be placed in proper position of the proving ground in order to detect any leaks of aerosols from the test site. In the event of leaks, protective measures should be available to populations at risk; that is, gas masks and protective clothing. The only known antidote to nerve gas poisoning is atropine (22, 28, 30, 32). This may be used in conjunction with oximes (cholinesterase reactivating agents). In some cases, artificial respiration is necessary also, and sometimes additional treatment for convulsions. The antidote usually has to be administered within a few minutes after exposure if the

victim is to be saved, and atropinization maintained for 24 hours. It is routine in laboratories and plants which work with nerve gas to have atropine-filled syringes readily available on wall brackets for instant use. Therefore, a large number of atropine-loaded syringes should be available for instant use in the vicinity of the proving ground in order to save the lives of the people who might be exposed to the gas. However, heavy exposure to the nerve gas requires a spectrum of medical care, not simply a shot of atropine, and atropine itself is a dangerous drug requiring medical management. The amount of atropine given must be carefully balanced against the symptoms of the poisons.

Not only around Dugway, but in the vicinity of every arsenal manufacturing this material, and along every transportation route when it is moved from place to place, emergency evacuation and medical plans should be available. They should be openly discussed by the medical community. Congress and the public should be told what precautions can be taken and what the possibilities are that they will be truly effective under the emergency conditions requiring rapid action, and affecting many people.

To return to the interagency committee's recommendation that "restricted open-air testing of persistent lethal agents be permitted" we wish to cite their statement that an accident which could require mass casualty evacuation "might occur only one time every 25 years * * *."

No one can predict the occurrence of such an accident. Nor can we anticipate the effects of such an accident, even with the best safety precautions, and medical care available, particularly for a civilian population unaware of the problem. In effect, the ad hoc committee is saying the risk to the people of Utah is acceptable because of the benefits of chemical testing. Such a decision is not medical, but political and economic.

Please comment on the interagency committee's recommendation (p. 2) that the toxic cloud itself may cross U.S. Highway 40 after 3 hours.

In regard to exposure of populations to testing, we do not understand the interagency committee recommendation on page 2 (8) that after a test at Dugway the toxic cloud may be permitted to cross U.S. Highway 40 after 3 hours. If the cloud is at too high an altitude to contaminate the ground at Highway 40, would it not exceed the height limitation of 300 feet? If, on the other hand it was low and crossed Highway 40, which is approximately 30 miles distance from the test site, it would contaminate the highway. The report suggests that no testing should be done if rain clouds in the area are a possibility within 8 hours because of the threat of scavenging of the toxic cloud by the rain and, therefore, precipitation in the environment off the test ground. Because of the difficulty of making firm weather forecasts, it would appear that the gas should not be permitted to cross Highway 40 at all or Highway 40 should be closed for the duration of the test, and for some hours subsequently. All available data suggests that the persistent highly lethal gas might endanger the lives of anyone crossing through it on Highway 40 within 3 hours. Could not detectors be put at the highway to determine concentration of gas? Is the concentration of gas as it passes Highway 40 known? Have detectors been placed throughout the test site to determine the concentrations of gas under given conditions? After all, 300 prior tests have been carried out and until the sheep-kill it was not even known that the gas had leaked from the test ground on that occasion.

Considering the known and unknown risks involved, do you approve, as a physician, repeated release of persistent, anticholinesterase compounds into even a small portion of the continental atmosphere?

The risks of release of anticholinesterase compounds into the continental atmosphere must be weighed against the benefits accrued by the atmospheric testing of these agents.

Certain of the risks of testing nerve gases are precisely those which have led the military to develop them for use in war: that is, toxicity, invisibility, ease of distribution, persistence, and the difficulty of treatment.

But there is another characteristic which makes them both hazardous to our own citizens during peacetime and of questionable value militarily; namely, their unpredictability. Targeting is highly dependent upon conditions such as weather and topography which are beyond human control. Further, just as an accident with this material in peacetime could be devastating, an accident in wartime could destroy thousands of our own military personnel or civilians on either side.

That there are hazards from our own nerve gases to our own population has become overwhelmingly clear within the past year. First, the sheep-kill in the

spring of 1968 in Utah; second, the revelation by independent Colorado scientists in the summer of 1968 that billions of lethal doses of nerve gas were stored close to Denver, and in the path of planes landing and taking off at the Denver airport; third, the proposal just 2 weeks ago of a hazardous method of disposing of out-of-date gas. This is not the first of the disposal problems. The Rocky Mountain Arsenal's deep disposal wells for chemical waste were blamed for a series of earthquakes in Denver, and that disposal method had to be abandoned. Now the proposal to ship 1,100 carloads of mustard and nerve gas across the country has also opened up the question of the safety of routine transportation of these agents from the places where they are manufactured to the test grounds and storage areas.

Sometimes they are shipped in tanks, sometimes they are loaded into shells, or bomb clusters with explosives. In some cases the chemicals themselves or the explosives, or both have aged. The aging of organophosphates has already been mentioned. All explosives are dangerous, but aged explosives are notoriously unpredictable—they may be more difficult to set off, or on the other hand they may be extremely unstable and may detonate all too easily. Hazardous materials of various kinds are frequently involved in accidents—the most recent example being the ammunition train accident near Los Angeles on May 15. As more gas is made, shipped, stockpiled, tested, and disposed of the chances of significant accidents increase rapidly. Even one accident poses a tremendous danger to the environment because of the amount and toxicity of the agents and the secrecy surrounding their presence.

We believe that anticholinesterase compounds, such as nerve gases, do constitute a danger to the population and environment. The dangers include not only the field testing and consequent possible exposure of susceptible populations, but also the disposal of waste or byproducts materials, the leakage of stored materials, and the disposal of out-of-date gases. The fact that 27,000 tons of out-of-date gas, a large portion of which is nerve gas, may be disposed of by ocean burial constitutes a serious threat to the environment as well as the people along the transportation route.

We would like to direct your attention to another issue raised by the ad hoc committee's report. Our reading of the report regarding testing safety at Dugway has raised a more profoundly disturbing possibility than the accidental killing of 6,000 sheep. On page 4 of the ad hoc committee's report (7), the following statement appears:

"Dugway Proving Ground has supported a sizable ecology and epidemiology program over the past 17 years covering the proving ground and surrounding areas. This program has been designed particularly to relate to the biological testing that has been conducted at the proving ground."

And on page 27, is this statement:

"Rigorous planning is followed in the design tests involving toxic and *infectious* materials." [Our emphasis.]

It has been well known that bacteria, viruses and rickettsiae are being studied at Ft. Detrick as possible weapons of war (*4, 6, 13, 20, 21, 24, 26, 29*). These have been tested on laboratory animals and some diseases like "Q-fever," which are seldom lethal, have been induced in animals and people as part of the research program. Field testing of bacteria not pathogenic to man has already taken place. In 1960 at a conference sponsored by the American Chemical Society (*12*), Fothergill described field trials using an aerosol of 130 gallons of bacillus subtilis (a harmless bacteria) as spore suspension released from the deck of a naval vessel 2 miles offshore. Prevailing winds blew the aerosol to the shore where sampling stations were set up. The cloud was sampled for 23 miles downwind, approximately 100 square miles of area sampled. Fothergill said, "It is likely that an even greater area was covered, particularly downwind." A recent trial (1960) with a vegetative pathogen (that is, infective) infected guinea pigs for 15 miles downwind of an area from the origin of the aerosol. Fothergill said, "Extrapolated calculations suggested that the aerosol probably travelled a good deal further than that of sample distance." Here is another example of the use of live organisms in field trials with the probability of extension beyond the sample station. The organisms used apparently were nonpathogenic for man but the stage was set for air testing of the biologicals with questionable safety measures being taken and with unknown dispersion of the aerosol.

Two recent articles (*12, 27*) suggest that field testing of Venezuelean equine encephalitis virus has been or may be carried out at Dugway. This virus has

been cited as being particularly suitable for biologic warfare. Studies regarding the infectivity of the virus at 12,000 feet simulated altitude have been reported (*12*). The financial support for this research was by Fort Detrick. Another article in "Bacteriological Reviews" (*27*) reports sampling for the presence of antibodies to Venezuelan equine encephalitis in mammals and birds in Utah. Antibodies were found, indicating the presence of this virus in the animal population in Utah, which had not previously been noted. This study is no proof that VEE has been field tested at Dugway, although that is one possible explanation for the presence of the virus. Another is that the virus had been brought by birds or in some other natural manner from South America, where it is endemic. In this case the investigation may have been undertaken as a baseline study in preparation for field testing or it may have been simply an effort to better understand a disease which is being researched for biological warfare but is still in the laboratory stage.

Dr. John S. Foster, Director of Defense Research and Engineering, Department of Defense, was asked by the Committee for Environmental Information, whether field testing of biological agents is being done. A copy of the letter follows:

"JANUARY 14, 1969.

"Dr. JOHN S. FOSTER, JR.,
"*Director of Defense Research and Engineering,*
"*Department of Defense, Washington, D.C.*

"DEAR DR. FOSTER: A recent report issued by the Department of the Army contains statements which raise important questions that we hope you can answer for us.

"This report is 'Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground.' The report states:

" 'Dugway Proving Ground has supported a sizable ecology and epidemiology program over the past 17 years covering the proving ground and surrounding areas. This program has been designed particularly to relate to the biological testing that has been conducted at the proving ground.' (P. 4.)

" 'Rigorous planning is followed in the design of tests involving toxic and infectious materials.' (P. 27.)

"One possible interpretation of these statements is that the Dugway Proving Ground is engaged in experimental operations which involve the deliberate release of infectious agents pathogenic or otherwise, into the natural environment. If this were the case, serious questions would be raised, we believe, about possible biological and medical consequences of Dugway Proving Ground test program which would need to be examined by the scientific community.

"Specifically we should be grateful for answers to the following questions:

"(1) Have cultured micro-organisms or viruses been released, either deliberately or accidentally into the environment (that is, areas not confined within a closed space) on the Dugway Proving Ground? If so, what agents have been released deliberately? Accidentally?

"(2) Apart from the Dugway program, do any current or past programs under the cognizance of the Department of Defense involve deliberate release of cultured microorganisms or viruses into open environmental areas? If so, what agents have been released, and at what locations?

"We would appreciate an early reply to these inquiries.

"Sincerely yours,

"SCIENTIFIC DIVISION, COMMITTEE FOR ENVIRONMENTAL INFORMATION.
"MALCOLM L. PETERSON, M.D.,
"*Chairman.*
"BARRY COMMONER, Ph. D.,
"*Member, Executive Committee.*
"M. W. FRIEDLANDER, Ph. D.,
"*Member, Executive Committee.*"

Dr. Foster replied on February 12, 1969:

"Dr. MALCOLM L. PETERSON,
"*Chairman, Committee for Environmental Information,*
"*St. Louis, Mo.*

"DEAR DR. PETERSON: This is in reply to a letter from the Committee for Environmental Information, dated January 14, 1969, signed by you and Drs. Commoner and Friedlander.

"As you know, most of the Defense Department's research and development related to maintaining a deterrent and defense against chemical and biological weapons is classified. The United States position on the use of chemical and biological warfare is quite unequivocal. We have never used biological warfare. We have not used chemical warfare since World War I, when it was used in retaliation. During World War II President Roosevelt announced the policy that the United States would not be the first to use chemical warfare. This was reiterated by President Eisenhower and by President Truman. It was stated several times by members of President Johnson's administration. A concise statement of the U.S. position in this area was made to the Subcommittee on Disarmament by the Honorable Cyrus Vance when he was Deputy Secretary of Defense. Briefly, he stated that we are actively seeking the liquidation of chemical and biological weapons through the United Nations, while maintaining a credible technological and military capability to the extent necessary to deter the use of those weapons by our adversaries. I am enclosing an excerpt from Mr. Vance's testimony.

"We recognize that almost any chemical and biological testing operations could pose environmental problems. We have been cognizant of these since the inception of the Dugway Proving Ground, as witnessed by the detailed ecological and epidemiological surveys to which you referred. To the best of our knowledge, there have been no ecological changes and no increase in the reservoir of endemic disease, in the several thousand square mile area covered by the continuing surveys.

"In addition, all of our activities at Dugway have been frequently examined by representatives of the scientific community. This has been done by specially constituted groups such as the one whose report you quoted and by a permanent advisory group. Membership on these includes both qualified governmental and nongovernmental scientists. Further, all of the activities of Dugway Proving Ground are known, in advance, to representatives of the U.S. Public Health Service and health officials of the State of Utah. Although most of these activities are classified in the best interests of our national security, none of the information has been withheld from the advisory and regulatory groups.

"Sincerely,

"JOHN S. FOSTER, JR."

Paragraph 3 implies that biological field testing is being carried out. Accordingly, we again wrote Dr. Foster on February 28, 1969:

"Dr. JOHN S. FOSTER, Jr.,
"*Director of Defense Research and Engineering,*
"*Department of Defense,*
"*Washington, D.C.*

"DEAR DR. FOSTER: Thank you for your reply of February 21 to our inquiry of January 14. However, your letter did not answer our inquiries. We had asked the following questions:

"1. Have cultured micro-organisms or viruses been released, either deliberately or accidentally into the environment—that is, areas not confined within a closed space—on the Dugway Proving Ground?

"2. Apart from the Dugway program, do any current or past programs under the cognizance of the Department of Defense involve deliberate release of cultured micro-organisms or viruses into open environmental areas?

"We would appreciate an affirmative or negative reply to each of these questions or a statement to the effect that the information requested is classified.

"You state that all activities at Dugway have been frequently examined by representatives of the scientific community, and that the examining bodies include a permanent advisory group. How long has this group been in existence? May we have a list of the members, with their professional affiliations? We are particularly interested in knowing what procedure exists for rapid review and release of information to the public in the event of another accidental release of chemical or biological agent to an offsite area. We would also like to know whether there is any mechanism for public discussion of the benefits and risks of chemical and biological testing.

"Sincerely yours,

"MALCOLM L. PETERSON, M.D.,
"*Chairman, Scientific Division.*"

To date, we have not received an answer.

Many of the agents in biological warfare programs are contagious. Even if the disease induced is not contagious, the agents are living material and their fate in the environment, that is, the development of mutations and the proliferation of these organisms, is not well understood. We do not understand how or why natural epidemics start, spread, and maintain themselves. Therefore, the fate of biological agents in the field is unknown and uncontrollable. Monitoring of biological agents is even more difficult than that of chemical agents. Control of a disease once it starts to spread may be difficult and control may be achieved only after a large cost in illness and death.

We believe that an immediate and thorough investigation into this testing program should be undertaken under congressional auspices by an interagency advisory committee similar to that which dealt with chemical safety or by a committee of scientists independent of the Government. It should begin immediately, especially since the ad hoc committee's report and reports from Fort Greeley, Alaska, suggest that such agents are already being released into man's environment. The investigation should obtain and make public the answers to the questions: What biological agents are being field tested? What is the technique of dissemination—that is, aerosols, insect vectors, or others? What are the monitoring procedures required on proving grounds? Do present regulations allow the field testing of an agent of a contagious disease? Do present regulations allow field testing of any biological agent without firm evidence of (*a*) successful methods for treating the disease it induces; or (*b*) specific plans for controlling the spread of the disease it induces?

All the questions about the manufacture, transportation, testing, and use of chemical weapons are still more urgent in reference to biological weapons. The unpredictability of biological weapons is even greater than that of chemical weapons.

We are apparently building larger and larger stockpiles of these uncertain weapons of mass destruction, and now have more than enough to kill all the people in the world. At the same time, we are trying to find ways to dispose of some of the "surplus" outdated chemical war gas.

We appear to be just on the threshold of a series of ever-increasing problems if we continue on our present course.

We believe that what is needed is an end to the secrecy surrounding these agents. Classified information should be released so that it can be independently evaluated. An open end discussion of the risks—the price the country may have to pay in terms of human and environmental exposure—may then be balanced against the foreign policy and military considerations which are considered to justify their manufacture and testing and ultimately their use. Until the secrecy is lifted and the risks, benefits, and precautions are known, we believe that no valid decision about continued release of these biological agents can be reached.

REFERENCES

1. Boffey, P. M.: Nerve Gas: Dugway Accident Linked to Utah Sheep-kill. *Science* 12:1460–1464, 1968.
2. Brodine, V., Gaspar, P. P., Pallmann, A. J.: The Wind from Dugway. *Environment* 11:2–9, 40–43, 1969.
3. Brown, F. J.: *Chemical Warfare, A Study in Restraints.* Princeton University Press, Princeton, N.J., 1968.
4. Chemical and Biological Warfare: *Scientist and Citizen*, 9:113–172, 1967.
5. Chromatographic Identification of Bacteria. Public Health Reports 81:1124–1125, 1966.
6. Clarke, R.: *The Silent Weapons, the Realities of Chemical and Biological Warfare.* David McKay Co., Inc., New York, 1968.
7. Department of the Army Report of the Interagency Ad Hoc Committee for Review of Testing Safety at Dugway Proving Ground, Washington, D.C., November, 1968.
8. Department of Health, Education, and Welfare, Health Services and Mental Health Administration DP, National Communicable Disease Center, Atlanta, Investigation of Sheep Deaths, Skull Valley, Utah.
9. Dille, J. R., Smith, P. W.: Central Nervous System Effects of Chronic Exposure to Organophosphate Insecticides. *Aerospace Medicine* 35:475–478, 1964.

10. Dudman, R.: Pentagon Defends Nerve Gas Disposal Plan. Denies Hazard. *St. Louis Post-Dispatch*, May 8, 1969.
11. Durham, W. F.: Pesticide Exposure Levels in Man and Animals. *Arch Environ Health* 10: 842–846, 1965.
12. Ehrlich, R.; Effect of High Altitude on Resistance to Inhalation VEE Virus Infection. *Arch Environ Health* 16: 469–471, 1968.
13. Fothergill, L. D.: The Biological Warfare Threat in Nonmilitary Defense: Chemical and Biological Defense in Perspective. Advances in Chemistry Series #26, American Chemical Society, Washington, D.C., 1960.
14. Ganelin, R. S.: Mail, G. A., Cueto, C. Jr.: Hazards of Equipment Contaminated with Parathion. *Arch Environ Health* 816–828, 1964.
15. Gardner, A. L., Iverson, R. E.: The Effect of Aerially Applied Malathion on an Urban Population. *Arch Environ Health* 16: 823–826, 1968.
16. Hartwell, W. V., Hayes, G. R., Jr.: Respiratory Exposure to Organic Phosphorus Insecticides. *Arch Environ Health* 11: 564–568, 1968.
17. Hartwell, W. V., Hayes, G. R., Jr., Funckes, A. J.: Respiratory Exposure of Volunteers to Parathion. *Arch Environ Health* 8: 820–825. 1964.
18. Hayes, G. R., Jr., Funckes, A. J., Hartwell, W. V.: Dermal Exposure of Human Volunteers to Parathion. *Arch Environ Health* 8: 827–833, 1964.
19. Healy, J. H., Rubey, W. W., Griffs, D. T., Raleigh, C. B.: The Denver Earthquakes. *Science* 161: 1301–1310, 1968.
20. Hersch, S. M.: *Chemical and Biological Warfare, America's Hidden Arsenal.* The Bobbs-Merrill Co., New York, 1968.
21. Janssen, W. A., Surgalla, M. J: Plague Bacillus: Survival within Host Phagocytes. *Science* 163: 950–952, 1969.
22. Juul, P., Spiess, F.: Cholinesterase Inhibitors: Pharmacology, Symptoms of Poisoning, and Treatment. Studies on the Cholinesterase Activities in Glaucoma Patients. *Military Medicine* 132: 501–511, 1967.
23. Meleney, W. P., Peterson, H. O.: The Relationship of Shelf Age to Toxicity of Dimethoate to Sheep. JAVMA 144: 756–758, 1964.
24. Meselson, M.: A Proposal to Inhibit the Development of Biological Weapons. 14th Pugwash Conference on Science and World Affairs, Venice, 11–16, April, 1965.
25. Palmer, J. W., Danz, J. W.: Tolerance of Brahman Cattle to Organic Phosphorus Insecticides. JAVMA 144: 143–145, 1964.
26. Robinson, J. F.: *Chemical Weapons in CBW: Chemical and Biological Warfare*, Steven Rose, editor, Beacon Press, Boston, 1969.
27. Sidwell, R. W., Gebhardt, L. P., Thorpe, B. D.: Epidemiological Aspects of Venezuelan Equine Encephalitis Virus Infections. *Bact Rev* 31: 65–81, 1967.
28. Sim, V. M.: Chemicals Used as Weapons in War in Dull's *Pharmacology in Medicine*, J. D. Palmer, editor, McGraw Hill, Inc., New York, 1965, third edition.
29. Symposium and Control of Foreign Nucleic Acid Held at Fort Detrick, Md., 4–5 April 1968, *Bact Rev* 32: 291–299, 1968 (part 1).
30. Van Meter, W. G., Karcymar, A. G.: Prophylactic and Antedotal Treatment of Sarin Poisoning with Drugs Given Singly and in Combination. *Arch Int Pharmacodyn* 172: 62–72, 1968.
31. Vercruysse, A.: Acute Parathion Poisoning. *J. Forensic Medicine* 11: 107–119, 1964.
32. World Health Organization Expert Committee on Insecticides: Safe Use of Pesticides in Public Health. World Health Org. Tech. Rep. ser. 356: 5–65, 1967.
33. Zacks, S. I. Blumberg, J. M.: Simple and Inexpensive Anti-Cholinesterase Detectors for Field Use. *Military Medicine* 129: 1084–1086, 1964.
34. Commoner, B.: *Science and Survival*, Viking Press, New York, 1966.
35. United States Senate, Committee on Foreign Relations. Chemical-Biological-Radiological (CBR) Warfare and Its Disarmament Aspects. XI, 43 pp. Washington, D.C., Government Printing Office, 1960.

Dr. DAVIS. I abstracted and will limit my comments.

The Committee for Environmental Information (CEI) provides scientific information relevant to political and social issues, without bias or prejudgment, in the belief that the dissemination of such in-

formation is necessary if citizens are to participate in a democratic society in a technological age. We publish "Environment" (formerly "Scientist and Citizen") containing information about the effects on the environment of various technologies, the peaceful and military uses of nuclear energy, and chemical and biological agents.

In 1967 CEI published a special issue on chemical and biological warfare. In January 1969 we published an article, "The Wind From Dugway," which was concerned with the escape of a chemical warfare agent in Utah in the spring of 1968.

Mr. Chairman, you asked that we address ourselves to certain specific questions. I will repeat the questions and then answer them to the best of our ability, although in many cases the information you would like to have is apparently not known or remains classified.

The fact that this information is not available is a deadly serious matter. If Congress and the people are to make the vital decisions about the manufacture, testing, and use of these agents—decisions which may determine the life or death of hundreds of thousands of our people—they must have the facts. If scientists outside the military are to contribute their expertise to the resolution of these problems, we must have the facts.

There was testimony before Congress as long ago as 1960 advocating increases in our chemical and biological warfare effort, but the hazards of testing, transportation, and disposal were not presented. Since that time our stockpiles have vastly increased, but many of the necessary facts are still not available. This country has had previous unhappy experience with leaving questions of this nature to the military, and to scientists consulted by the military in secret.

The dangers of atmospheric testing of nuclear weapons were also secret during the early years of that testing. Scientific discussion was limited to small, secret committees. It was not until the whole subject was brought out into the open, and classified information released, that the errors of the military and their scientific consultants could be corrected, and that Congress and the public could play their proper role in decisionmaking.

You asked:

> What are the hazards to human beings and animals of breathing aerosols or dust particles containing or contaminated by highly toxic chemicals, with special reference to the tiny quantities of VX which can produce physiological effects per unit of animal weight?

The highly toxic chemicals referred to are forms of organophosphates—the nerve gases, the pesticides, and the antiparasite drugs act in the body in the same way. They block cholinesterase, producing a severe central nervous system disorder. Certain nerve impulses are transmitted by a natural chemical, acetylcholine; after transmitting the impulse to muscle or organs, the acetylcholine is destroyed by another natural substance called cholinesterase. If the action of the cholinesterase is blocked by one of the organophosphate poisons, the acetylcholine continues to send its now inappropriate signals throughout the body, and the functions of the brain, the digestive system, and the respiratory system—all the body's functions are rapidly thrown into a state of disorder.

The specific toxicity of VX and similar nerve gases is not available in the open literature. It was clear from the recommendations made

by the Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground that there were also many facts about its toxicity to people, to animals and to plants that were not known to the Army. If the toxicity were well understood it would not have been necessary for the ad hoc committee to recommend that:

> Determination or estimation be made of the toxic and lethal activities of single and repeated doses of the chemical by intravenous, intramuscular, subcutaneous, oral, inhalation, and cutaneous injection or application, on humans or animals. . . .

as well as other laboratory and ecological studies. Whether these studies have now been done and the answers found is not known to us.

The toxicity to a few animal species was determined, and was given in the report of the National Communicable Disease Center. For example, the LD–50 (the dose which would kill half of the subjects exposed) when absorbed through the skin is 1.2 milligrams for 40-kilogram sheep. If men were equally sensitive, an 80-kilogram man (about 180 pounds) could be killed by 2.4 milligrams. That is about eighty-four millionths of an ounce. However, sheep may be much more susceptible to this nerve agent than people.

Another way to approximate the lethality of VX is to compare it with the Swedish "F" agent, which has been reported to be five times as toxic as Soman. Soman is one of the "G" agents, an early nerve gas, now outmoded by the "V" agents. The LD–50 of Soman has been reported to be 1,250 milligrams for a man. "F" gas would therefore be lethal at a dose of 250 milligrams.

The subcommittee asked:

> What is the relative toxicity and persistence of VX as compared to other organophosphate compounds, for example, the insecticide, parathion?

The pesticide parathion, an organophosphate poison, has been reported to be nontoxic when applied to the skin in large amounts at 2 percent concentrations.

When either of these organophosphates is inhaled (parathion of VX), it acts more readily and at smaller doses than when absorbed through the skin, but the specific toxicity is not known for either agent by the respiratory route. The average lethal dose of Sarin, another "G" agent, when inhaled, is 1 milligram. VX is more toxic than Sarin.

In regard to the persistence of VX, information is not available. Apparently the Army, at the time of the sheep-kill incident, was also not in possession of all the facts as the ad hoc committee recommended that the toxicity and persistence of residues of the compound on test sites and other areas be determined. Parathion is persistent for more than 125 days at 25° C. Recommendations have been made that orchards sprayed with 8 ounces of parathion per acre be closed for 21 days. VX is classified as "persistent" but just how persistent is not known to us. The persistence, volatility, and particle size can be varied by the vehicle or solvent the gases are carried in, and the means of distribution. The agents can also be mixed with other materials which may increase their toxic effect and which may make treatment more difficult.

There is considerable variation among species in sensitivity to the agents. Published data concerning the effect of organophosphate pesticides on various animals show that different species, even different

breeds of the some species, have differing susceptibilities to organophosphates. Brahman cattle appear to be much more susceptible to the action of certain organophosphates used in spraying and for treatment of parasites than other breeds of cattle. Sheep are highly sensitive to methoate which is used against parasites.

It is interesting to note that the longer the shelf age of dimethoate, the more toxic it becomes to sheep. It would be interesting to know whether the same applies to the related nerve gases. For example, the "G" agents that had been stored for 20 years and were to be dumped in the ocean—has their toxicity been increasing during their 20 years on the shelf?

The subcommittee asked:

Is the recommendation of the interagency committee that restricted open air testing of persistent, lethal agents be permitted, consistent with its medical recommendation that a mass casualty and medical evacuation procedure be developed and tested annually?

The Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground approved the precautions and medical care taken there. At that time the protection of the civilian population on and off the base was sharply questioned.

Open-air testing of nerve gases has recently been resumed. At the time the ad hoc committee's report was released, the Army announced that all its recommendations had been adopted.

We have included certain questions and comments in our statement.

To return to the interagency committee's recommendation that "restricted open air testing of persistent lethal agents be permitted . . ." we wish to cite their statement that an acicdent which could require mass casualty evacuation ". . . might occur only one time every 25 years . . .''

No one can predict the occurrence of such an accident nor can we anticipate the effects of such an accident, even with the best safety precautions, and medical care available, particularly for a civilian population unaware of the problem. In effect, the ad hoc committee is saying the risk to the people of Utah is acceptable because of the benefits of chemical testing. Such a decision is not medical, but political and economic.

The subcommittee asked:

Please comment on the interagency committee's recommendation (p. 2) that the toxic cloud itself may cross U.S. Highway 40 after 3 hours.

In regard to exposure of populations to testing, we do not understand the interagency committee recommendation on page 2 that after a test at Dugway the toxic cloud may be permitted to cross U.S. Highway 40 after 3 hours. If the cloud is at too high an altitude to contaminate the ground at Highway 40, would it not exceed the height limitation of 300 feet? If, on the other hand, it was low and crossed Highway 40, which is approximately 30 miles distance from the test site, it would contaminate the highway. The report suggests that no testing should be done if rain clouds in the area are a possibility within 8 hours because of the threat of scavenging of the toxic cloud by the rain and therefore precipitation in the environment off the test ground. Because of the difficulty of making firm weather forecasts, it would appear that the gas should not be permitted to cross Highway 40 at

all or Highway 40 should be closed for the duration of the test, and for some hours subsequently. All available data suggests that the persistent highly lethal gas might endanger the lives of anyone crossing through it on Highway 40 within 3 hours. Could not detectors be put at the highway to determine concentration of gas? Is the concentration of gas as it passes Highway 40 known? Have detectors been placed throughout the test site to determine the concentrations of gas under given conditions? After all, 300 prior tests had been carried out and until the sheep-kill it was not even known that the gas had leaked from the test ground.

The subcommittee asked:

Considering the known and unknown risks involved, do you approve, as a physician, repeated release of persistent, anticholinesterase compounds into even a small portion of the continental atmosphere?

The risks of release of anticholinesterase compounds into the continental atmosphere must be weighed against the benefits accrued by the atmospheric testing of these agents.

Certain of the risks of testing nerve gases are precisely those which have led the military to develop them for use in war; that is, toxicity, invisibility, ease of distribution, persistence, and the difficulty of treatment.

But there is another characteristic which makes them both hazardous to our own citizens during peacetime and of questionable value militarily; namely, their unpredictability. Targeting is highly dependent upon conditions such as weather and topography which are beyond human control. Further, just as an accident with this material in peacetime could be devastating, an accident in wartime could destroy thousands of our own military personnel or civilians on either side.

That there are hazards from our own nerve gases to our own population has become overwhelmingly clear within the past year.

First, the sheep-kill in the spring of 1968 in Utah;

Second, the revelation by independent Colorado scientists in the summer of 1968 that billions of lethal doses of nerve gas were stored close to Denver, and in the path of planes landing and taking off at the Denver airport;

Third, the proposal, just 2 weeks ago, of a hazardous method of disposing of out-of-date war "gas." This is not the first of the disposal problems. The Rocky Mountain Arsenal's deep disposal wells for chemical waste were blamed for a series of earthquakes in Denver, and that disposal method had to be abandoned. Now the proposal to ship 1,100 carloads of mustard and nerve gas across the country has also opened up the question of the safety of routine transportation of these agents from the places where they are manufactured to the test ground and storage areas.

Sometimes they are shipped in tanks, sometimes they are loaded into shells, or bomb clusters with explosives. In some cases the chemicals themselves or the explosives, or both, have aged. The aging of organophosphates has already been mentioned. All explosives are dangerous, but aged explosives are notoriously unpredictable—they may be more difficult to set off, or on the other hand they may be extremely unstable and may detonate all too easily. Hazardous materials of various kinds are frequently involved in accidents—the most recent example being the ammunition train accident near Los Angeles on May 15.

As more gas is made, shipped, stockpiled, tested, and disposed of, the chances of significant accidents increase rapidly. Even one accident poses a tremendous danger to the environment because of the amount and toxicity of the agents and the secrecy surrounding their presence.

We believe that anticholinesterase compounds, such as nerve gases, do constitute a danger to the population and environment. The dangers include not only the field testing and consequent possible exposure of susceptible populations, but also the disposal of waste or byproduct materials, the leakage of stored materials, and the disposal of "out-of-date" gases. The fact that 27,000 tons of out-of-date gas, a large portion of which is nerve gas, may be disposed of by ocean burial constitutes a serious threat to the environment as well as the people along the transportation route.

We would like to direct your attention to another issue raised by the ad hoc committee's report. Our reading of the report regarding testing safety at Dugway has raised a more profoundly disturbing possibility than the accidental killing of almost 6,000 sheep. On page 4 of the ad hoc committee's report, the following statement appears:

> Dugway Proving Ground has supported a sizable ecology and epidemiology program over the past 17 years covering the proving ground and surrounding areas. This program has been designed particularly to relate to the biological testing that has been conducted at the proving ground. * * *

And, on page 27, is this statement:

> Rigorous planning is followed in the design of tests involving toxic and infectious materials. * * *

It has been well known that bacteria, viruses, and rickettsiae are being studied at Fort Detrick as possible weapons of war. These have been tested on laboratory animals and some diseases like "Q-fever," which are seldom lethal, have been induced in animals and people as part of the research program. Field testing of bacteria not pathogenic to man has already taken place.

In 1960 at a conference sponsored by the American Chemical Society, Fothergill described field trials using an aerosol of 130 gallons of bacillus subtilis (a harmless bacteria) as spore suspension released from the deck of a naval vessel 2 miles offshore. Prevailing winds blew the aerosol to the shore where sampling stations were set up. The cloud was sampled for 23 miles downwind; approximately 100 square miles of area were sampled. Fothergill said:

> It is likely that an even greater area was covered, particularly downwind.

A recent trial—1960—with a vegetative pathogen—that is, infective—infected guinea pigs for 15 miles downwind of an area from the origin of the aerosol. Fothergill said:

> Extrapolated calculations suggested that the aerosol probably traveled a good deal further than that of sample distance.

Here is another example of the use of live organisms in field trials with the probability of extension beyond the sample station. The organisms used apparently were nonpathogenic for man but the stage was set for air testing of the biologicals with questionable safety measures being taken and with unknown dispersion of the aerosol.

Two recent articles in the scientific literature suggest that field testing of Venezuelan equine encephalitis (VEE) virus has been or may be carried out at Dugway. This virus has been cited as being particularly suitable for biologic warfare. Studies regarding the infectivity of the virus at 12,000 feet simulated altitude have been reported. The financial support for this research was by Fort Detrick.

Another article in "Bacteriological Reviews" reports sampling for the presence of antibodies to Venezuelan equine encephalitis in mammals and birds in Utah. Antibodies were found, indicating the presence of this virus in the animal population in Utah, which had not previously been noted. This study is not proof that VEE has been field tested at Dugway although that is one possible explanation for the presence of the virus.

Another explanation is that the virus had been brought by birds or in some other natural manner from South America where it is endemic. In this case the investigation may have been undertaken as a baseline study in preparation for field testing or it may have been simply an effort to better understanding a disease which is being researched for biological warfare but is still in the laboratory stage.

Dr. John S. Foster, Director of Defense Research and Engineering, Department of Defense, was asked by the Committee for Environmental Information whether field testing or biological agents is being done.

Dr. Foster replied on February 12, 1969, and in his paragraph 3 implies that biological field testing is being carried out. Accordingly, we again wrote Dr. Foster on February 28, 1969, and to date have not received an answer.

Many of the agents in biological warfare programs are contagious. Even if the disease induced is not contagious, the agents are living material and their fate in the environment, that is, the development of mutations and the proliferation of these organisms, is not well understood. We do not understand how or why natural epidemics start, spread, and maintain themselves. Therefore, the fate of biological agents in the field is unknown and uncontrollable. Monitoring of biological agents is even more difficult than that of chemical agents. Control of a disease once it starts to spread may be difficult and control may be achieved only after a large cost in illness and death.

We believe that an immediate and thorough investigation into this testing program should be undertaken under congressional auspices by an interagency advisory committee similar to that which dealt with chemical safety or by a committee of scientists independent of the Government. It should begin immediatley, especially since the ad hoc committee's report and reports from Fort Greeley, Alaska, suggest that such agents are already being released into man's environment.

The investigation should obtain and make public the answers to the questions:

What biological agents are being field tested?

What is the technique of dissemination; for example, aerosols, insect vectors, or others?

What are the monitoring procedures required on proving grounds?

Do present regulations allow the field testing of an agent of a contagious disease?

Do present regulations allow field testing of any biological agent without firm evidence of (*a*) successful methods for treating the disease it induces; or (*b*) specific plans for controlling the spread of the disease it induces?

All the questions about the manufacture, transportation, testing, and use of chemical weapons are still more urgent in reference to biological weapons. The unpredictability of biological weapons is even greater than that of chemical weapons.

We are apparently building larger and larger stockpiles of these uncertain weapons of mass destruction, and now have more than enough to kill all the people in the world. At the same time, we are trying to find ways to dispose of some of the "surplus" outdated chemical war gas.

We appear to be just on the threshold of a series of ever-increasing problems if we continue on our present course.

We believe that what is needed is an end to the secrecy surrounding these agents. Classified information should be released so that it can be independently evaluated. An open end discussion of the risks—the price the country may have to pay in terms of human and environmental exposure—may then be balanced against the foreign policy and military considerations which are considered to justify their manufacture, testing, and ultimately their use. Until the secrecy is lifted and the risks, benefits, and precautions are known, we believe that no valid decision about continued release of these chemical and biological agents can be reached.

Mr. REUSS. Thank you.

Mr. Vander Jagt, there are four or five witnesses whose testimony is, in my judgment, having seen their statements, somewhat complementary. I am wondering if you agree that it would be most useful to hear the witnesses before examining them. I think that might be the way to proceed.

If you will just remain at the table, Dr. Davis, I would now like to ask Dr. Sidel, Mr. Williams, Dr. Osguthorpe, and Dr. Van Kampen. to come forward. These gentlemen are respectively Dr. Victor W. Sidel, chief of the community medicine unit, Massachusetts General Hospital; Mr. Philip Williams, Jr., Staff Meteorologist for the Scientific Services Division, Western region of the U.S. Weather Bureau; Dr. D. A. Osguthorpe, who is a prominent veterinarian and consultant to the Utah State Department of Agriculture; and Dr. Kent R. Van Kampen, a veterinary pathologist with the Agricultural Research Service of the U.S. Department of Agriculture at Logan, Utah.

I will ask Dr. Sidel to present his statement.

First, let me thank all you gentlemen for preparing for us the very capable statements you have submitted. Without objection they will all be admitted into the record and I am going to ask each witness in turn, as I have Dr. Davis, to compress his oral presentation into the minimum amount of time needed to tell the story.

Dr. Sidel?

STATEMENT OF DR. VICTOR W. SIDEL, CHIEF, COMMUNITY MEDICINE UNIT, MASSACHUSETTS GENERAL HOSPITAL; ASSISTANT PROFESSOR OF MEDICINE, HARVARD UNIVERITY MEDICAL SCHOOL

Dr. SIDEL. Thank you.

A word of identification: I am a graduate of Princeton University and the Harvard Medical School; I have had special training in internal medicine, in biophysics, and in epidemiology and biostatistics. I am currently assistant professor of medicine at the Harvard Medical School and chief of the Community Medicine Unit at the Massachusetts General Hospital; I am also a consultant to the U.S. Public Health Service, and have been a special consultant to the American Medical Association.

I have recently returned from Geneva where I served as a consultant to the World Health Organization in the preparation of a technical report on the health effects of possible use of chemical and biological weapons; I am also the author of a number of articles on chemical and biological weapons and their medical consequences.

Of course, I testify as an individual in these hearings, and do not in any way represent these organizations for which I work or for which I have been a consultant.

I am pleased to be invited by the subcommittee to testify at these hearings. The open-air testing of chemical weapons, which has been acknowledged by the Department of the Army, and the possible, although recently denied, field testing of biological weapons, have been of deep concern to me as a physician, as a scientist and as a citizen.

As a physician, my concern has been with the medical and public health hazards of the development and testing of these weapons. I am especially concerned about the anticholinesterase agent—nerve gas—VX because of its extreme toxicity and persistence. This agent is rapidly lethal if absorbed through the skin, inhaled through the lungs, or ingested into the mouth. The toxicity of VX has never to my knowledge been published in the open literature by the U.S. Army. However, the Swedish Ministry of Defense has stated that between 2 and 10 milligrams—that is, between 2 and 10 thousandths of a gram or about 1 ten-thousandth of an ounce—of an agent similar to VX is fatal when placed on a man's skin; this quantity is so small that it is essentially invisible—*Forsvarets Forskninganstalt*: "BC-stridsmedel" FOA orienterar OM No. 2, 1964, revised June 1967. VX is therefore about 2,000 times as toxic by skin absorption as mustard gas, and about 300 times as toxic through the lungs. Robinson, J. P., in "CBW: Chemical and Biological Weapons," edited by S. Rose, Becaon Press, Boston, 1969. While it is difficult to make a direct comparison between VX and the insecticide parathion, which has caused many accidental deaths in this country and abroad, VX would appear to be at least an order of magnitude—that is, 10 times more toxic by the respiratory route and at least two orders of magnitude—that is, 100 times—more toxic by the skin absorption route.

Details on the persistence of VX are likewise very difficult to ascertain. It is known to be much less volatile (that is, to evaporate at a much slower rate) than the nerve gases of the "G-series." The article

in Science, the journal of the American Association for the Advancement of Science, on the accident last March at Dugway Proving Ground in Utah which killed some 6,000 sheep, suggests that sheep continued to ingest VX and to become ill for at least 3 weeks after the incident. The difficulties in the detoxification or destruction of such substances are further suggested by the Army's plan (New York Times, May 9, 1969) to ship "obsolete but still lethal gas * * * by rail from Rocky Mountain Arsenal near Denver and the Edgewood Arsenal in Maryland to the Naval Ammunition Depot at Earle, N.J. There it would be loaded into four old Liberty ships, which would be towed 250 miles to sea and sunk." Furthermore, it has apparently been necessary to discard waste products from the manufacturer of such weapons into deep underground wells under Denver; this method of waste disposal was uncovered when it became clear that recent Denver earthquakes were caused by this waste fluid being pumped underground under high pressure (New York Times, March 26, 1966). Thus chemical weapons do not even need to be open-air tested to pose a danger to conservation and natural resources.

It may be of interest to the subcommittee that the symptoms in humans of poisoning with nerve agents include chest tightness, nausea, vomiting, confusion, shortness of breath, excess salivation, incontinence of urine and feces, collapse, convulsions, and death; death can occur within minutes of exposure. The action of the agent is to block the enzyme cholinesterase which destroys the substance acetylcholine at nerve endings and permits the muscles to relax; the muscles are therefore unable to relax and it has been aptly stated that in nerve gas poisoning the body's organs strangle themselves to death. If the victim lives there can be residual brain damage due to lack of oxygen or other neurological disorder, but the most usual course for nonfatal doses is recovery within a week. Treatment must be begun almost instantaneously and involves decontamination, use of artifical respiration, and administration of atropine, prelidoxime, and anticonvulsant medication (Sims, V. M. in "Drill's Pharmacology in Medicine," J. R. DiPalma, editor, McGraw-Hill, New York, 3d edition, 1965).

Turning from nerve gas to biological weapons, Mr. Chairman, you asked Congressman McCarthy about the previous history of biological warfare. It is a bit of Massachusetts lore that Lord Jeffrey Amherst, in his wars with the Indians, smuggled blankets which had been contaminated by association with smallpox victims to the Indians and thereby attempted—it is not clear whether he succeeded—to start a smallpox epidemic among the unprotected Indians.

Mr. REUSS. You may be provoking disorder on the Amherst campus——

Dr. SIDEL. I bring this up because of the point raised earlier about the presence of an Indian reservation so close to the Dugway Proving Ground.

As a physician I am concerned about the evidence, published in Bacteriological Reviews in 1967, that antibodies against Venezuelan equine encephalitis (VEE) have been found in cattle in Utah. This is the only State in the United States in which such antibodies have been found except for Florida and Louisiana, in which such antibodies would be more expected. This fact, together with the known

interest in VEE as a biological weapon, because it is so easily spread to humans by inhalation of airborne material and because there is little immunity to it in temperature-zone nations, suggests that there may have been field testing of this agent in Utah. The Army has denied such testing, but in view of its initial denial of responsibility for the sheep disaster it is hard to know how much credence to place in its denials.

For the subcommittee's interest, the incubation period of VEE is 2–5 days, with very sudden onset of headache, fever, malaise, chills, nausea or vomiting, and severe muscle pain. Severe encephalitis or generalized illness may occur. Symptoms persist in mild cases for 3 to 5 days and for as long as 8 days in more severe attacks. Prompt and complete recovery usually takes place, but a case fatality rate of about 0.5 percent (1 death in each 200 cases) has been reported, with the deaths concentrated among children under age 15. An experimental vaccine is available from Fort Detrick, but "administration of the vaccine is limited to persons who are considered to be 'at risk' to infection because of occupation or other similar circumstances." (Sidwell et al., Bacteriological Review, March 1967.)

As a scientist, I am concerned about safety measures, about the use and misuse of scientific institutions, and about the validity of information supplied by Government agencies. I am not reassured by the statement by Congressman Lloyd that there was no gross negligence in the case of the accident at Dugway. If that accident could occur in the absence of negligence, this is even more worrisome than had negligence occurred. It is a well-known principle in the use of dangerous materials that anything that can go wrong will eventually go wrong if the materials are used often enough, despite the most elaborate of safety precautions. The application of this principle to chemical and biological weapons is reinforced by the episode of March 13, 1968, at the Dugway Proving Ground. It is now open knowledge—although to my knowledge not yet publicly acknowledged by the Department of the Army—that a malfunction in one of the pressurized tanks used to spray VX in liquid droplet form from a low-flying aircraft caused the death of some 6,000 sheep grazing in Skull Valley, Utah, about 27 miles away from the drop area. Details of the accident may be found in Science for December 27, 1968, in Environment, the journal of the Committee for Environmental Information, for January–February 1969, and in the Journal of the American Veterinary Medical Association for March 15, 1969. In addition, Medical World News for April 12, 1968, quotes Dr. Kelly H. Gubler, the chief of the staff of the Tooele Valley Hospital, 50 miles to the east of the proving ground: "* * * I've treated workers in the past for an overdose of anticholinesterase agents, even though the Army denied they were contaminated at the proving ground."

The fact that these accidents occurred despite the most stringent safety precautions offered little confidence that the new safety recommendations made by the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground (Department of the Army, November 1968) will be any more successful in preventing future accidents. For example, the committee recommends (page 2) that the toxic cloud "not cross U.S. Highway 40 for at least

3 hours"; there is no reason, at least in the open literature, to believe that it will be universally true that all toxic clouds will have dispersed sufficiently in 3 hours to be of absolutely no risk to motorists or others on U.S. Highway 40, 35 miles north of Dugway. An indication that the committee itself is not certain of the absolute efficacy of the measures it recommends is its advocacy (page 31) of the "development and maintenance of a plan of action in the event of off-post contamination from testing of chemical agents."

As Dr. John H. Millburn, another physician from Tooele, put it in an interview quoted in Medical World News: ". . . I don't consider even Tooele immune from Dugway chemicals. We should bear in mind that with a slight amount of misdirected contaminant, there could be a massive human disaster."

With regard to the use and misuse of scientific institutions, the subcommittee is certainly familiar with the recent disclosure by NBC television news that a Smithsonian Institution bird-banding project in the South Pacific had been initiated and supported by the U.S. Army. While the extent of the use by the Army of the Smithsonian Institution as a "cover" for biological weapons activities (the phrase used by NBC News) is not clear ("Science" February 21, 1969), it is certainly clear that the international scientific reputation of the Smithsonian is certain to have suffered by the disclosures of the association of the Smithsonian Institution with military activities and the secrecy imposed. It would appear to me that this subcommittee should have some interest in keeping institutions like the Smithsonian free from this kind of taint.

(In response to a subcommittee inquiry, Dr. S. Dillon Ripley, Secretary of the Smithsonian Institution, subsequently wrote to Chairman Reuss as follows concerning the Institution's Pacific oceanic bird project:)

SMITHSONIAN INSTITUTION,
Washington, D.C., June 5, 1969.

Hon. HENRY S. REUSS,
Chairman, House Subcommittee on Conservation and Natural Resources, Rayburn Building, Washington, D.C.

DEAR CONGRESSMAN REUSS: The research project which we call the Pacific oceanic bird project involves fundamental scientific research in the fields of ornithology and ecology and is a continuation of research that was initiated but was not carried to completion, during the Whitney Expedition[1] of the late 1920's and early 1930's. It comprises an ecological survey of the Central Pacific, an area covering some 4⅓ million square miles of open ocean dotted with clusters of islands and atolls. The major goals of the survey are to learn what plants and animals occur on the islands in this vast region, the seasonal variations in their numbers and reproductive activities and in addition to learn more about the factors which determine the distribution and abundance of the birds of the open ocean.

To date the work has resulted in the publication of 45 scientific papers appearing in reputable scientific journals that are available throughout the world. The extent to which the published fundamental scientific data derived from this project may be useful to U.S. Federal agencies or for that matter to governmental agencies and research organizations in other countries anywhere in the world is certainly beyond the limits of our knowledge.

I wish to assure you that the Smithsonian Institution has not engaged in biological warfare research, insinuations in press reports and television notwithstanding.

[1] Of the Museum of Natural History in New York.

Although the project received funds from the Army and although entry into militarily restricted areas and the use of military vessels in reaching the areas involved obtaining limited clearances for our people in the field, the Army posed no restrictions upon us in the conduct of the research and our publications have not been censored in any way. The propriety and even the advisability of the Smithsonian's acceptance of funds from the Department of Defense have been called into question since the recent publicity. It should be understood that a considerable part of the basic research presently being undertaken throughout the country in Government agencies as well as in the universities is supported by funds from various Government agencies including the Department of Defense. The Smithsonian Institution as well as these other organizations accepts money from as many outside sources as possible. Money is accepted however for research that our scientists propose, and with the full understanding that all findings may be published in open scientific literature. Unfortunately, our own funds are insufficient to permit the kind of research that we feel we must undertake if the sciences of systematics and ecology are to advance.

I hope this explanation will put the problem into proper perspective for you. Please do not hesitate to communicate with us further if you wish any additional information.

Sincerely yours,

S. DILLON RIPLEY,
Secretary.

Dr. SIDEL (continuing with prepared statement). As a scientist I am also disturbed, and I hope the members of the subcommittee are disturbed, at the misinformation given by the Army at the time of the Dugway accident. Not only is there evidence that many of the sheep might have been saved had there been prompt disclosure, but questions are raised about the relationship between the executive branch of the Government and the Congress, the scientific community and all of its citizens.

As a citizen, finally, I am convinced that there are no reasons for this type of testing which outweigh the clear risks. I am sure that there are occasions when certain risks must be taken for the greater good of the community or of the Nation or the world. This is not such an occasion. On the contrary, there is every reason—political, strategic, medical, and moral—for us to refrain from development, testing, or use of these weapons and to work for effective international arms control and disarmament measures in this area. There is no reason, in my view, for us to continue to risk the lives of our people and the contamination of our land.

This is the type of issue which may fall between the areas of concern of specific congressional committees. For example, this subcommittee may assume that the U.S. Army must continue to take risks in this area because the international aspects of CBW are in the province of the Foreign Relations Committee of the Senate; yet the Foreign Relations Committee may assume that they need not concern themselves with domestic dangers of these weapons because such dangers are in the province of this subcommittee. As a result neither committee may receive a full picture and neither committee may take effective action to reduce the dangers.

May I therefore respectfully recommend to the subcommittee that it take the initiative in finding methods to insure:

(1) Cessation of all open-air testing of chemical weapons;

(2) If biological weapons are being field tested, cessation of all field tests of biological weapons; if they are not being tested, a ban on all such testing.

(3) Removal of all secrecy in microbiological research; and

(4) Work with the appropriate committees of the Congress and of the executive branch to end all development, production, and use of such weapons by:

(a) Ratification by the United States of the Geneva Protocol of 1925; and

(b) Work with other nations through the Eighteen Nation Disarmament Conference and through the United Nations to find effective means of chemical and biological arms control and disarmament.

The subcommittee may wish to know that these recommendations are endorsed by the Council of Health Organizations, a coordinating group which includes representatives of the Physicians for Social Responsibility, the Physicians Forum, and the Medical Committee for Human Rights. Together, these groups speak for a large number of concerned physicians in the United States. These physicians hope this subcommittee will take prompt and effective action against the dangers posed by chemical and biological weapons.

Thank you.

Mr. REUSS. Thank you Dr. Sidel.

We will now hear from Mr. Williams.

(Mr. Williams' prepared statement follows:)

PREPARED STATEMENT OF PHILIP WILLIAMS, JR., ASSISTANT CHIEF, SCIENTIFIC SERVICES DIVISION, WEATHER BUREAU, WESTERN REGION, ESSA, DEPARTMENT OF COMMERCE

Mr. Chairman and members of the subcommittee, I am please to be here today at the invitation of this subcommittee to discuss wind and weather conditions in northwestern Utah, particularly the movement of fine particles in the atmosphere.

In general, airborne particles, such as dust and other aerosols, move with the approximate direction and speed of the wind. Very small particles (diameter in the order of, equal to, or less than, 1 micron or 1 millionth of a meter) tend to remain in suspension or fall out very slowly, and thus can be transported many miles. For example, the average size of smoke particles is about 0.1 micron, and smoke from cities has been observed several hundred miles downwind. Smoke from forest fires in northwest Alberta, Canada, has been observed 2,000 miles downstream at U.S. east coast cities. On the other hand, larger particles or droplets of size greater than 100 microns fall out of the atmosphere in a relatively short period, usually a matter of minutes, and therefore are not ordinarily transported great distances. The transport of aerosols is greatly influenced by weather conditions, especially wind and air mass stability. Wind direction determines the direction of travel of pollutants, while speed determines travel time from source to receptor. Another effect of wind speed is dilution in the downwind direction; that is, the greater the wind speed, the greater the dilution.

Turbulence, that is, random air motions of widely different scales and periods, is responsible for diffusion of airborne particles about the mean or average downwind path. Turbulence may be of two general types. Mechanical turbulence is induced by the roughness of the surface over which air is passing. In general, the rougher the surface and the faster the wind movement, the greater the turbulence. The other kind is called thermal turbulence. It is induced mainly when air is heated by the underlying earth's surface, and is related to stability of the air. For example, the stronger the daytime heating, the greater the thermal turbulence and the greater the vertical motions in the air. These motions, in turn, produce a mixing of air layers at different heights and thus a vertical transport of aerosols takes place. When the air mass is very stable, as is usually the case at night, there is relatively little vertical mixing, hence little turbulence. Effects of turbulence, then, are to diffuse pollutants as they are carried along by the wind, and thus reduce their concentration. In general, diffusion rates are high and concentrations of pollutants are relatively low when winds are strong and the

air is moving over much warmer ground. Diffusion rates are low and concentration relatively high when winds are light and the air mass stable, as on a cold, clear, calm night. Diffusion models are available for calculating degrees of pollutant concentration under varying degrees of stability and windspeed.

The weather patterns in and round Great Salt Lake Desert of northwest Utah vary considerably, particularly by season.

Consider first the fall. At this time of year there is a maximum frequency of high-pressure systems over the area. These "highs" stagnate over the Great Basin for periods of several days to several weeks. Storms moving in from the Pacific Ocean are relatively infrequent. Under these stagnant high-pressure systems, fair skies generally prevail, and local wind regimes dominate the circulation patterns. These local winds consist of drainage (downslope) flow at night and early morning hours, and upslope or valley winds during the late forenoon and afternoon. Nocturnal temperature inversions are frequent during this period. This last is a condition where air temperatures near the surface are colder than those slightly above the ground. This results in a stable stratification of the air mass, which in turn inhibits the mixing of air layers near the ground with those above. Thus, any pollutants trapped beneath the inversion would be slow to disperse.

In some years, the rather stagnant conditions described above will persist into early winter. Inversion conditions may persist throughout the day at this time of year. In general, however, the frequency of storms moving in from the Pacific tends to increase as winter begins. Cold fronts, that is, the leading edge of a moving cold air mass, are usually preceded by strong southerly or southwesterly winds as they approach the Great Salt Lake area. With the passage of the cold front, winds shift suddenly to a northwesterly direction and are fairly strong for a few hours, then gradually diminish. A rapid drop in temperature is noted, along with showers of snow or rain. Precipitation may be heavy over the mountains, but is usually light and of fairly brief duration over desert and valley areas. Clearing behind the front is fairly rapid, except over the higher mountains.

Moving into spring, we find that the frequency of storm systems over northwestern Utah reaches a maximum. Normally, spring is the wettest season in the area. In addition to the frontal systems described above, there is a maximum frequency of upper-air closed-low-pressure systems. These low-pressure systems form over the western plateau at high levels, say 20,000 feet, above the ground. They are usually accompanied by widespread rain and snow. Precipitation over valleys and deserts is relatively heavy as compared to that over the mountains. In other words, there is usually less dependence on orographically produced precipitation than with the frontal systems described earlier. The upper lows, which extend through deep layers of the atmosphere, have built-in mechanisms for rising air motions. These rising air currents are essential for significant amounts of precipitation.

If the winter season has been quite dry, strong southwesterly winds in advance of spring cold fronts will pick up large amounts of dust and loose soil from desert areas and salt flats, blowing it for many miles over urban areas of northwestern Utah. If the cold front should be accompanied by only a very light rain or snow, this dust or alkali material will be deposited out, leaving a grayish-white coating on buildings and automobiles.

Moving into the summer season, the frequency of storms of Pacific origin decreases rapidly over northwestern Utah, and late June and early July are normally the driest times of the year. However, later in July and through August, the large-scale flow pattern shifts from a generally westerly direction to a more southerly or even southeasterly direction. These air currents bring in moisture at high levels from the Gulf of Mexico and the warmer waters of the Pacific Ocean off the coast of Mexico. This moist air mass becomes unstable as it moves over the sun-heated plateau, and convective showers and thunderstorms break out. Showers are most frequent over the mountains, but occasionally extend out over the valleys. Thunderstorms occur on 6 or 7 days per month on the average over valley and desert areas in summer. Rainfall from these storms is usually light, widely scattered, and covers only small areas. However, with a strong influx of moisture, thundershowers can become heavy. These are sometimes of the so-called cloudburst or gully-washer type. Moist southerly currents as described above usually alternate during summer with drier air currents from the southwest. During these latter periods, temperatures reach their highest of the year, occasionally exceeding 100° at valley locations.

31-509—69——5

The approximate level of confidence in weather forecasts in the Great Salt Lake area is also related to seasonal variations. Commencing with the fall, stagnant high-pressure systems are frequently present over the area as described earlier. Under these conditions, the weather is highly predictable, as fair skies and light winds usually prevail and precipitation is largely absent. Under such a regime, it is possible to assign a zero probability of precipitation occurrence to many days with high confidence. The local wind regimes described earlier—that is, the strength of upslope and downslope winds, the time of diurnal shift from nighttime to daytime circulation, and the relationship of winds to the local topography, etc.—are well handled by forecasters experienced in mesoscale patterns of the area.

As storminess increases in winter, difficulties with predictions also increase. Problems arise with timing and strength of frontal systems as they move from the Pacific Ocean into the Great Basin. It is seldom, if ever, possible to assign as high a confidence to precipitation occurrence forecasts as to no-precipitation forecasts, especially in dry regions such as the Great Salt Lake Desert. This is because over the area of concern it is much easier to predict rain-inhibiting factors, such as large high-pressure systems, surface and aloft, than it is to predict the relatively infrequent rain-producing factors, which are usually of a smaller scale, such as frontal systems, moist air currents, and upper-air troughs and low-pressure systems. Local topographic effects are also very important factors in the prediction of precipitation. Thus, forecasts made for days when no precipitation occurs are, in general, much more likely to be correct than forecasts for days when precipitation does occur. Also, amounts of precipitation over valley and desert areas are highly variable and difficult to predict.

These same difficulties with frontal systems are still present in spring. At this time the difficulty is further increased by the problem of correctly forecasting development and movement of upper-air closed-low-pressure systems. These systems are associated with widespread precipitation and reach their maximum frequency in this season. Fortunately, recent improvements in numerical prediction models by the National Meteorological Center in Suitland, Md., have markedly increased the accuracy of forecasts of these upper-air lows, and there is reason to hope that these models will continue to be improved in future years. Computer-produced forecasts have also resulted in improvements in forecasting the movement of frontal systems which sweep across northwestern Utah in the colder season.

In summer, even though there is less weather to predict in the area of concern, difficulties in forecasting are perhaps greater. This is because of the scattered nature of summer thunder showers and their limited area coverage. It is usually possible to predict that on certain days some thunder shower activity will occur in the general area of the Great Salt Lake, using large-scale flow patterns and air mass stability criteria. However, it is very difficult to pinpoint the location of the showers, as areal coverage of precipitation on thunderstorm days is frequently only 10 to 20 percent. Strong gusty surface winds usually accompany thunderstorms, so they are quite important when considering local dispersal of aerosols.

In response to the request for comments on the relevance of the above items to movement of toxic aerosols and contaminated dust particles from Dugway Test Site to surrounding areas I would make the following observation.

Under the stagnant high-pressure systems which occur frequently in fall and winter, and less frequently in other seasons, winds would be generally light, and local wind regimes tend to prevail. Ordinarily, very little transport of aerosols out of a basin or closed valley would be expected. There would, however, be air movement within the basin or valley, i.e., downslope at night and up valley in the afternoons. In an area with a marked diurnal regime, this within valley transport could be considerable. When frontal systems move across the Great Basin, considerable transport of aerosols for relatively great distances could be expected, especially with the stronger cold fronts of late winter and spring. Ahead of these fronts southerly or southwesterly surface winds of 25 to 35 miles per hour occur frequently, even exceeding 40 miles per hour at times. These winds pick up and transport dust and loose soil for many tens of miles. When a cold front moves slowly or stalls over eastern Nevada, these strong, gusty southerly winds may persist for several days. After passage of the cold front, winds shift to a northwesterly direction. These winds may reach speeds of 30 to 40 miles per hour behind strong cold fronts. In spring, behind fast-moving fronts, gusts have been known to reach 75 miles per hour at Wendover,

on the western edge of the Salt Flats, where northwesterly winds are funneled out of a canyon. At Salt Lake City Airport, post cold frontal winds in March have reached 70 miles per hour. Strong winds such as these can, of course, resuspend ground particles and move them great distances. In summer, wind movements are more erratic and localized. Winds associated with thunderstorms can reach 40 to 50 miles per hour in brief gusts, and create localized dust storms, but transport of airborne material over great distances would ordinarily not occur.

In response to the subcommittee's invitation to comment on the two reports furnished I would offer the following with respect to the "Report of the Interagency Ad Hoc Committee for Review of Testing Safety at Dugway Proving Ground," November 1968, with reference particularly to page 25, paragraph 4a. In my opinion there also exists the need for a capability to predict subsynoptic weather systems whose dimensions lie between 50 and 300 miles. This need exists in particular because of the frequent occurrence in northwest Utah of rapidly moving cold fronts, with winds up to 40 miles per hour especially during spring months.

Thank you for having invited me to appear before this subcommittee. If you wish I would be happy to answer any questions at this time.

STATEMENT OF PHILIP WILLIAMS, JR., ASSISTANT CHIEF, SCIENTIFIC SERVICES DIVISION, WEATHER BUREAU, WESTERN REGION, ESSA, DEPARTMENT OF COMMERCE, SALT LAKE CITY, UTAH

Mr. WILLIAMS. Since my statement is lengthy I prepared a summary for oral presentation. I have attempted to respond to your questions posed in your letter to me requesting me to appear.

I am pleased to be here today at the invitation of this subcommittee to discuss wind and weather conditions in northwestern Utah, particularly the movement of fine particles in the atmosphere.

Transport of aerosols is greatly influenced by weather conditions, especially wind and air mass stability. Wind direction determines the direction of travel of pollutants, while speed determines travel time from source to receptor. Very small particles tend to remain in suspension or fall out very slowly, and thus can be transported many miles. For example, smoke from cities has been observed several hundred miles downwind. Effects of turbulence are to diffuse airborne particles as they are carried along by the wind, and thus reduce their concentration. In general, diffusion rates are high and concentrations low when winds are strong and the air is moving over much warmer ground. Diffusion rates are low and concentrations relatively high when winds are light and the air mass stable, as on a cold, clear, calm night.

The weather patterns in and around Great Salt Lake Desert of northwest Utah vary considerably by season.

During fall, high pressure systems stagnate over the Great Basin for periods of several days to several weeks. Storms moving in from the Pacific Ocean are relatively infrequent. Under these stagnant "highs," fair skies generally prevail, and local wind regimes dominate the circulation pattern. Nocturnal temperature inversions are frequent during this period.

In general, the frequency of storms moving in from the Pacific tends to increase as winter begins. Cold fronts are usually preceded by strong southerly or southwesterly winds as they approach the Great Salt Lake area. With the passage of the cold front, winds shift suddenly

to a northwesterly direction and are fairly strong for a few hours; then they gradually diminish. A rapid drop in temperature is noted, along with showers of snow or rain. Precipitation may be heavy over the mountains, but is usually light and of fairly brief duration over desert and valley areas.

In spring, the frequency of storm systems over northwestern Utah reaches a maximum. In addition to the frontal systems described above, there is a maximum frequency of upper-air closed-low-pressure systems, which are usually accompanied by widespread rain and snow.

In summer, the frequency of storms of Pacific origin decreases rapidly over northwestern Utah, and late June and early July are normally the driest times of the year. However, late in July and through August, the large-scale flow pattern frequently brings in moisture at high levels. This moist air mass becomes unstable as it moves over the sun-heated plateau, and convective showers and thunderstorms break out. Rainfall from these storms is usually light, widely scattered and covers only small areas.

The approximate level of confidence in weather forecasts in the Great Salt Lake area also has seasonal variations. Under the stagnant high pressure systems of fall, the weather is highly predictable, as fair skies and light winds usually prevail. It is possible to assign a zero probability of precipitation occurrence to many days with high confidence. The local wind regimes are well handled by forecasters experienced in mesoscale patterns of the area.

As storminess increases in winter, difficulties with predictions also increase. Problems arise with timing and strength of frontal systems as they move from the Pacific Ocean into the Great Basin. Local topographic effects are very important factors in the prediction of precipitation. Also, amounts of precipitation over valley and desert areas are highly variable and difficult to predict.

In spring, the difficulty is further increased by the problem of correctly forecasting development and movement of upper-air closed-low-pressure systems. Recent improvements in numerical prediction models by the National Meteorological Center in Suitland, Md., have markedly increased the accuracy of forecasts of these upper-air lows, and there is reason to hope that these models will continue to be improved in future years.

In summer, difficulties in forecasting are perhaps greater because of the scattered nature of summer thundershowers and their limited areal coverage. It is usually possible to predict that on certain days some thundershower activity will occur in the general area of the Great Salt Lake, but it is very difficult to pinpoint the location of showers.

The relevance of above items to movement of aerosols and dust particles from Dugway Test Site to surrounding areas will now be considered.

Under stagnant high pressure systems, winds would be generally light, and local winds regimes tend to prevail. Ordinarily, very little transport of aerosols out of a basin or closed valley would be expected.

There would, however, be air movement within the basin or valley, i.e., downslope at night and up valley in the afternoons.

When frontal systems move across the Great Basin, considerable transport of aerosols for relatively great distances could be expected, especially with the stronger cold fronts of late winter and spring. Strong winds associated with these fronts pick up and transport dust and loose soil for many tens of miles.

In summer, wind movements are more erratic and localized. Winds associated with thunderstorms can reach 40–50 m.p.h. in brief gusts, and create localized dust storms, but transport of airborne material over great distances would ordinarily not occur.

I wish to thank you for inviting me to appear before this subcommittee and I would be happy to answer any questions you would like to pose.

Mr. REUSS. Thank you, Mr. Williams. Dr. Osguthorpe.

STATEMENT OF D. A. OSGUTHORPE (D.V.M.), VETERINARIAN; CONSULTANT TO UTAH STATE DEPARTMENT OF AGRICULTURE, SALT LAKE CITY, UTAH; SPECIAL REPRESENTATIVE OF GOVERNOR OF UTAH IN INVESTIGATION OF MARCH 1968 SHEEP DEATHS

Dr. OSGUTHORPE. Mr. Chairman and members of the subcommittee, my name is Dr. D. A. Osguthorpe. I appreciate your invitation to be here today. It was at the request of Governor Calvin Rampton and the Utah State Department of Agriculture that I entered into the investigation of the mysterious disease affecting some 6,000 sheep in the Skull Valley area in Utah.

These sheep first showed symptoms on March 14, 1968. Many were dead and others were recumbent and dying. Attending veterinarians thought it was possibly an outbreak of halogeton poisoning. Medication with calcium gluconate produced negative results.

March 15, 16, 17, and 18, the sheep continued to die and still showed signs of neuromuscular weakness. Those that were able to stand had a very abnormal head carriage. The neck, having an unusual arch, supported the head like a pendulum. The animals made frequent attempts to urinate.

On March 19, 1968, David R. Waldron, livestock commissioner, Utah State Department of Agriculture, and myself visited the White Rock herd. I autopsied several sheep adjacent to the fence which surrounds the Dugway Proving Ground on the east side. There were no pathological lesions that I could observe that may have caused the death of the sheep that I posted. There were no indications of ingestion of poisonous plants. The sheep were fat and in extremely good condition for this time of the year.

Thinking this may be an organic phosphate type of poisoning, I bled 10 of the affected ewes that were still able to walk. This blood was taken to the laboratory for cholinesterase determinations. The levels were below normal, ranging from 0.00 to 0.16 as read on the Delta pH scale. Normal reading is 0.20 to 0.25.

On March 20, 1968, I returned to the White Rock area. Having a good idea that this was an organic phosphate poisoning, after injecting several animals with atropine sulfate using the recommended therapeutic doses. No response was observed. I repeated the treatment several times, increasing the dosage each time. After giving several

times the normal therapeutic dose some of the animals were able to walk that had been unable to get on their feet. At this point I decided that this was a case of organic phosphate poisoning.

On March 21, 1968, having reported to the Utah State Department of Agriculture my findings, Governor Rampton invited me to accompany him by helicopter to make an inspection of the affected flocks, being five in number. Everything pointed to an organic phosphate poisoning. The ranchers in the area had done some spraying with chlorinated hydrocarbon compounds. They had not used any organic phosphate compounds. The Army denied using any organic phosphate compounds since last July of 1967.

The Army, being a prime suspect, was invited to meet with the Governor on March 22, 1968. Prior to this meeting they emphatically denied any use of organic phosphate compounds just prior to the onset of the conditions in the sheep. At this meeting they did admit of testing with these compounds on March 13, 1968. Governor Rampton advised that the military, meaning Dugway, were responsible and that arrangements should be made very shortly for them to pay the necessary indemnity for the sheep. He then appointed a correlation committee with Commissioner David R. Waldron as chairman, and Dr. D. A. Osguthorpe, practicing veterinarian, to represent the State department of agriculture, Dr. G. D. Carlyle Thompson, director of the State public health, Mr. Ward C. Holbrook, director of the State welfare, Mr. Marcellus Palmer, secretary of the Utah Wool Growers Association.

On March 26, 1968, arrangements were made to start burying the sheep. The Army provided the equipment and manpower.

Now began the investigation into how did it happen.

March 13, 1968, the day of the tests conducted by the Army at the Dugway Proving Ground, was a blustery day. Winds were from the southwest at 25 to 35 miles per hour, with gusts even greater. There were numerous clouds in the area with thunderstorm activity in the distance. A stationary front was lying to the northwest. The test runs, using a bis-simulant, an organic phosphate compound of low toxicity, were made during the day. Towards evening the actual test was made. An airplane flying at a high rate of speed carrying tanks filled with VX sprayed the grid area.

I might state that this airplane was flying at 150 feet above the ground. The gates on the tanks failed to close and some of the material was carried to heights greater than anticipated. This material was carried north by the wind and hence failed to fall or settle on the grid or test area. It was carried in this direction for more than 1 hour. Then the front passed through the area and with the wind direction change the material was carried to the southeast. By the time it reached the area where the sheep were, it had spread out over an area approximately 25 miles wide and 50 miles long. Here it rained and snowed and the material was scavenged from the air. This afforded an intake by the sheep by three routes.

First, the agent came in contact with their wool and skin. It fell on the forage that they were eating, and it came down on the snow

that they were eating and the water that they were drinking. As a result they received a lethal dose of the agent.

Upon my first visit to the Dugway Proving Ground, I was assured that there would be no danger from the agent 4 days after the tests were conducted. New sheep were introduced into the area and 4 to 5 days afterwards they began to show clinical symptoms similar to the first sheep. Subsequent tests proved that the agent was persistent and a sheep consuming 2 pounds of the dry June grass per day would develop clinical symptoms in 4 to 5 days.

Other animals in the area had depressed cholinesterase levels. Tests on the cattle and horses showed their levels to be depressed. Blood samples from sheep herds belonging to Deseret Livestock Co. to the north of the White Rock area had lowered cholinesterase levels. Rabbits and birds were affected. Rodents were also affected.

Sheep were taken to the Dugway Proving Ground for test purposes. The sheep that came from farms out of the area died with different symptoms than those coming from the immediate area. This indicated that the sheep from the area around the proving ground had possibly had previous exposure.

None of the laboratories in our area were equipped to identify the agent. The phosphorous peaks obtained through gas chromotography did not match those of the agent. Later it was determined that some of the P.O. peaks obtained were due to the bis-simulant used in the trial runs. Some were due to other tests, indicating this was not the first agent that had drifted from the designated test area. Some of the tests revealed the presence of products of decomposition of the compound due to hydrolysis, pyrolysis, and degradation. These products may be more toxic than the original agent.

The VX compound in question was finally identified by thin-layer gas chromotography.

Some of the organic phosphate compounds remain in the soil as long as 6 months. In this area the prevailing wind is from the west. Hence any compound remaining suspended in the air is carried eastward toward the densely populated areas of the Wasatch front; at least they do not have to travel only a short distance until they are off the Dugway Proving Ground. As storm fronts approach the area, the wind blows from the south and this carries airborne materials north over U.S. Highway 40. Upon passage of the frontal systems, the winds shift to the northwest. Winds from the northwest carry materials to the south toward Delta, Utah. In this area we have a farming area engaged in the raising of alfalfa seed. Considerable chemical spraying is done in the growing of this crop.

During the investigation of the Dugway incident, it was brought out that some of these chemicals used in pesticide control may be catalytic or synergistic in the toxicity of organic phosphate compounds.

There are great individual differences in susceptibility to organic phosphate compounds. This would account for the fact that some of the sheep showed no clinical symptoms. Also some of the herds more removed from the test area received a more dilute dose of the agent.

In the summertime this area where the Dugway Proving Ground is located is extremely dry. Dust storms are very common. Any compound present in the soil may be transported to areas where animals, wildlife, birds and waterfowl, and people live. Frequently dust from this desert area is carried to 20,000 feet drifting eastward to the Wasatch front and beyond.

Considerable sagebrush is sprayed in the State of Utah. This type of spraying is done at very low altitudes above the ground, yet considerable drifting of the chemicals used for this purpose occurs. Many lawsuits have developed due to crop and shrubbery damage.

It can be said that atmospheric testing of lethal chemical agents has many dangers. There is considerable knowledge to be learned before this type of testing can be safely carried on.

In summary, I would say that in order to continue chemical and biological testing at the Dugway Proving Ground in a safe manner considerate of all the people, animals and wildlife of the area, the boundaries of the proving ground should be extended and the modes of experimentation changed. There should be more closed atmospheric testing and less open atmospheric testing until the properties of the chemicals being used are more fully understood.

Thank you.

Mr. REUSS. Thank you, Dr. Osguthorpe.

Dr. Van Kampen.

STATEMENT OF DR. KENT R. VAN KAMPEN, VETERINARY PATHOLOGIST, AGRICULTURAL RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE, LOGAN, UTAH

Dr. VAN KAMPEN. Mr. Chairman and members of the subcommittee:

I appreciate the opportunity to appear before you to review the findings of the Department of Agriculture on the organic phosphate poisoning of sheep in Skull Valley, Utah. Since your invitation of May 9 for my appearance stressed particular interest in certain areas, I will address myself to those three questions specifically asked by you.

1. Did cattle and horses show despressed levels of cholinesterase in the period following the organic phosphate poisoning of the Skull Valley sheep in March 1968? If so, what accounted for the relatively lesser susceptibility of the cattle and the horses to the poison?

Cattle and horses within the contaminated area had depressed levels of cholinesterase activity but did not have clinical signs of the poisoning. The grazing habits of these animals may account in part for their apparent lessened susceptibility to the nerve agent; however, cholinesterase enzymes present in the serum of cattle and horses but virtually absent from the serum of sheep may have buffered the effect of the organophosphate on the nervous system of the cattle and horses.

2. Is it possible that the forage eaten by the grazing sheep had been subjected to tissue contamination by VX tests previous to

March 13, 1968? Are the forage plants perennials? Could the March 1968 sheep-kill have been the result of a combination of previous ingestion of contaminated plants as well as ingestion of new contamination on March 14?

It is not known if contamination was only on the surface of the plants (as would be expected if fallout from the March 13 tests was alone responsible), if the agent was present in the tissues of the plants (as is known to occur with some organophosphorus insecticides), or if both the plant surfaces and tissues were contaminated.

The cheat grass (bromus tectorum) is an annual. The cheat grass (gathered in April) that caused cholinesterase depression when fed to sheep experimentally was the previous year's growth. New grass collected in June and August did not induce cholinesterase depression. This would suggest that the contamination was on the surface of the plant and not due to incorporation of the organic phosphate agent from the soil into the tissues of the plants.

Black sage (artemisia nova), shad scale (atriplex confertafolia), and bud sage (artemisia spinescens) are perennial plants.

These four species of plants constituted the major portion of the diet of the sheep at the time of the poisoning.

3. With respect to feeding experiments conducted with contaminated forage in months following March 1968, what were the effects on sheep at the end of April, in June, and in August 1968? Were depressed cholinesterase levels noted on these dates? Did any sheep die as a result of these experiments?

On April 1, 1968, the four aforementioned species of forage plants from the various areas where the sheep became ill were collected. The same species of plants were collected from the northern end of Skull Valley, where no sheep had been ill, to be used as control material.

The collection of each species of plant was kept separate and was dried and ground. Each species of plant was then fed to a separate group of sheep. Amounts approximating normal daily consumption (2–3 pounds dried plant) were fed via stomach tube or rumen fistula, for a 10-day period. All sheep fed the plants collected from the area where the sheep died developed a marked depression of cholinesterase. The sheep fed bud sage and cheat grass developed clinical signs identical to those in the affected sheep in Skull Valley. One of the sheep fed cheat grass died 5 days after the experiment began with severe neuromuscular disorders, accompanied by a complete inhibition of cholinesterase activity.

Mr. REUSS. What was the date of death of that sheep?

Dr. VAN KAMPEN. I don't have that immediately available.

Mr. REUSS. Would you say the plants were collected on April 1, that they were then fed to the sheep for 10 days, and one of the sheep died 5 days after the experiment, so the death was——

Dr. VAN KAMPEN. The feeding trial——

Mr. REUSS. On or about the 10th of April.

Dr. VAN KAMPEN. The feeding trial began on the 4th of April after the plants had been collected so the sheep died sometime between the

evening of April 9 and the morning of April 10, 1968. I can clarify that for the record if you would like me to.

Mr. REUSS. Well, if your examination of your records shows any marked deviation from the dates of April 9 and 10 that you have given, please correct it. Otherwise it will stand.

Dr. VAN KAMPEN (continuing with prepared statement). Thank you.

No changes were observed in those sheep fed control forage from the northern end of Skull Valley.

Two additional collections of the four species of plants were made on June 12 and August 10, 1968. These were fed as previously described. A mild cholinesterase depression was induced by the black sage collected on June 12, 1968, but none of the other plants caused this change.

I would like to offer as additional material the published scientific report of our findings in connection with the poisoning of sheep in Skull Valley, Utah. This report appeared in the March 15, 1969, issue of the Journal of the American Veterinary Medical Association, volume 154, pages 623–630. I would also like to submit for the record a copy of the Agricultural Research Service report of August 30, 1968, on "Sheep Losses in Utah During March 1968."

(The materials referred to follow:)

[Reprinted from the Journal of the American Veterinary Medical Association, vol. 154, No. 6, pp. 623–630]

ORGANIC PHOSPHATE POISONING OF SHEEP IN SKULL VALLEY, UTAH

(Kent R. Van Kampen, D.V.M., Ph. D.; Lynn F. James, Ph. D.; Jordan Rasmussen, D. V. M.; Robert H. Huffaker, D. V. M.; Marr O. Fawcett, D. V. M.)[1]

SUMMARY

In the area of Skull Valley, Utah, approximately 6,278 sheep became ill after eating forage contaminated with an organophosphate compound. Of those affected, approximately 4,500 died or had to be killed. Clinical signs of the intoxication included generalized neuromuscular weakness, profuse nasal discharge, frequent micturition, torticollis, and scoliosis. Erythrocytic cholinesterase activity was severely depressed. There were no pathognomonic lesions on macroscopic or microscopic examination.

Skull Valley, Utah, located approximately 70 miles west of Salt Lake City (fig. 1) and lying between the Cedar and Stansbury Mountain Ranges, is primarily desert. Some alfalfa is grown in the valley, but most of the area is desert rangeland with native grasses and brushes. Livestock have grazed continuously in this area since 1890. Part of the valley is owned by ranchers, but most of it is Federal land administered by the Department of the Interior. At present, thousands of sheep and cattle are pastured in Skull Valley each year. Here, as in most of the mountainous West, livestock occasionally have been poisoned by ingesting toxic plants which grow in the area.

---

[1] Drs. Van Kampen and James are veterinary pathologist and animal nutritionist, respectively, at USDA, ARS, ADP Division, Logan, Utah 84321; Dr. Rasmussen is veterinarian in charge, USDA, ARS, ANH Division, Salt Lake City, Utah 84111; Dr. Huffaker is deputy chief Veterinary Public Health Section, National Communicable Disease Center, Public Health Service, Department of Health, Education, and Welfare, Atlanta, Ga. 30333; and Dr. Fawcett is a veterinary practitioner, Layton, Utah 84041.

The authors thank Dr. Wayne Binns, Mrs. Brenda Woodruff, and Mrs. Joyce Johnson of the Poisonous Plant Research Laboratory, Logan, Utah; Dr. Ross Smart, Utah State University, Logan, Utah; Dr. Steven Warnick, Utah State Public Health Pesticide Laboratory, Salt Lake City, Utah; Dr. Hillman Nelson, National Animal Disease Laboratory, Ames, Iowa; Mr. August Curley, National Communicable Disease Center, Atlanta, Ga.; Dr. Bernard MacNamara, Edgewood Arsenal, Edgewood, Md.; Dr. Mortimer Rothenberg, Dugway Proving Ground; and numerous others who participated in the investigation.

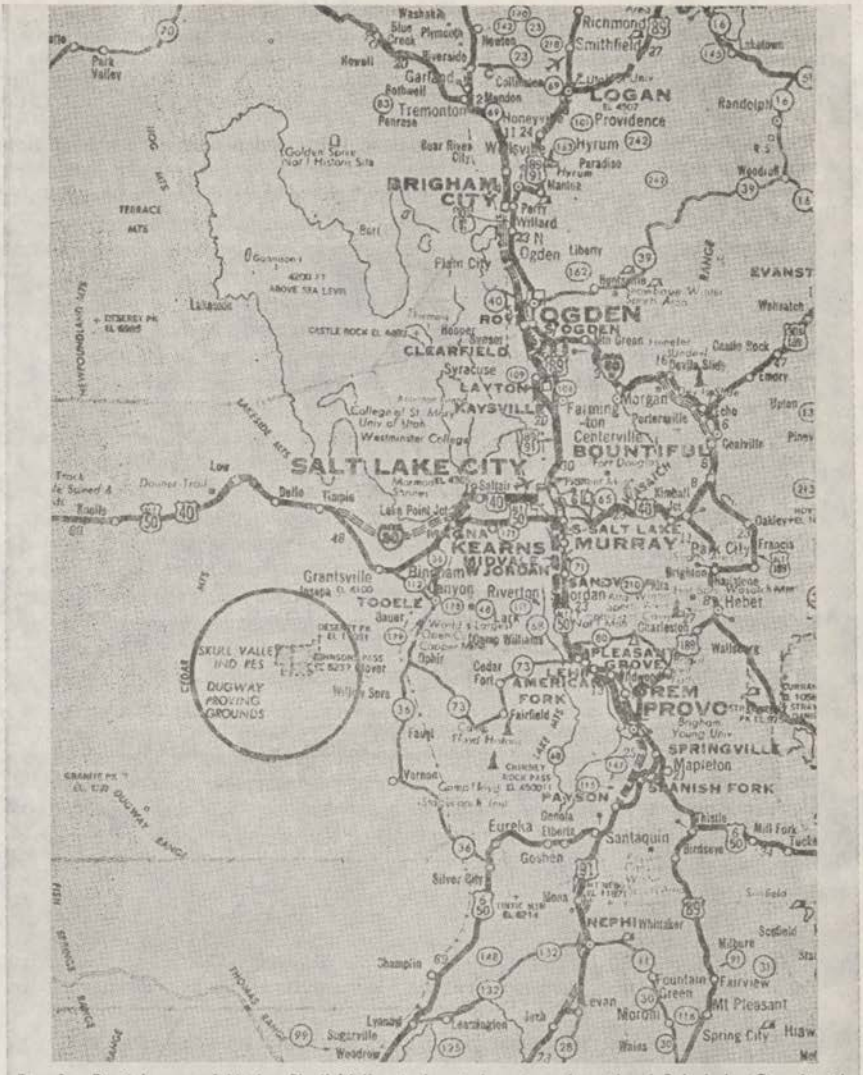


Fig. 1—Partial map of Utah. Skull Valley is located west and south of Salt Lake City (inside circle).

The southern and western borders separate Skull Valley from the Department of the Army's Dugway Proving Ground.

EPIZOOTIOLOGIC FINDINGS

On March 14, 1968, some of the 2,800 ewes grazing in the Cedar Mountains (fig. 2, band 1) were found to have signs of an illness described by the herder as "crazy in the head." Many of the sheep died during the night, and most of the others had characteristic signs of "Skull Valley disease" the next day. Also on March 14, ewes in another band of 2,800, grazing across the valley on the plain below the Stansbury Mountains (fig. 2, band 2), began to manifest signs identical to those observed in the first flock. A few died that evening, and almost all sheep in the flock became ill in the next few days. On March 17 and 18, signs

of the illness were observed in three other flocks of sheep in Skull Valley (fig. 2, bands 3, 4, and 5). The suckling lambs in band 3 were not affected. The ewes in this small flock were the only ones with nursing lambs at their side. On March 20, a few sheep in a band of 1,625 (fig. 2, band 6) located east of the Stansbury Mountains in Rush Valley also developed signs characteristic of the Skull Valley disease.

The morbidity and mortality of the disease decreased progressively from band 1 to band 6 (table 1).

Cattle, horses, dogs, people in the same general area as the ill sheep had no clinical signs of the illness.

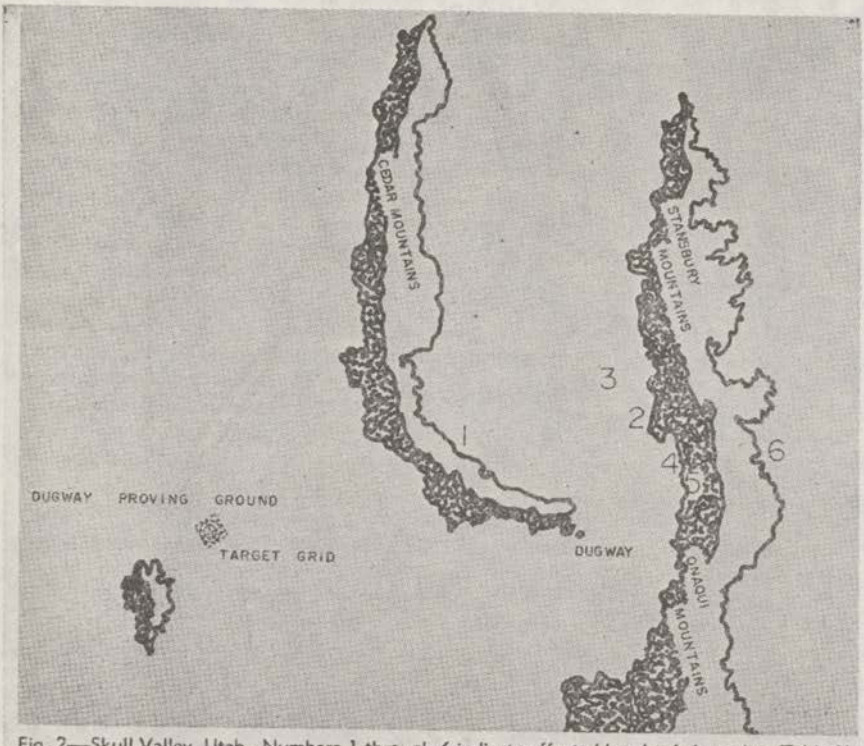


Fig. 2—Skull Valley, Utah. Numbers 1 through 6 indicate affected bands of sheep (see Table 1).

TABLE 1.—MORBIDITY AND MORTALITY DATA ON SHEEP AFFECTED BY NERVE AGENT

Band No.	Number of sheep	Morbidity	Mortality [1]
1	2,800	2,800	2,500
2	2,800	2,800	1,800
3	[2] 41	28	28
4	200	150	100
5	400	400	25
6	1,625	100	0
Total	7,866	6,278	4,453

[1] Includes those that were killed.
[2] Does not include nursing lambs.

One band of sheep located between bands 2 and 4 did not have signs of the disease. These sheep were lambing, were being maintained on alfafa hay, and had no access to natural forage. Bands of sheep grazing north and south of the affected sheep did not have signs of the disease.

The geographic area where the sheep became ill was triangular, with the apex of the triangle at the White Rock area of Skull Valley (area where band 1 was affected). This area was carefully studied for poisonous plants that cause acute illness in sheep and for arthropod vectors. Halogeton was growing in the range where band 1 was pastured but not in the other areas. The ill sheep were infested with sheep keds (*Melophagus ovinus*), but ticks were not found on the sheep or plants in the area.

There was not a common water supply for the affected bands of sheep. Some were eating snow, some were drinking from small ponds, and some were drinking well water. Some of the sheep were being fed mineral supplements. Neither the affected sheep nor the forage they were consuming had recently been sprayed with pesticides. Ewes were to lamb in May; almost all that were examined post mortem were pregnant, and both single and twin fetuses were seen. None of the sheep had been shorn.

CLINICAL SIGNS

The signs of the disease varied in intensity from band to band and from sheep to sheep. The most characteristic sign was marked weakness of the cervical musculature, resulting in flexion of the neck and causing the head to be carried with the mandible at right angles to the sternum. Many of the sheep had torticollis and thoracolumbar scoliosis. Most of them had a profuse, tenacious nasal discharge. Generalized myasthenia became apparent when the sheep were driven. Ill animals tired quickly and were poorly coordinated, and many apparently normal sheep fell when they attempted to jump. They were aware of stimuli such as noise and rapid movement, but their response to these stimuli was severely retarded. Sheep which were still standing made frequent attempts to urinate. Affected sheep had normal body temperatures. Ocular examination revealed a retarded pupillary response to light, but lesions were not visible. Consistent patterns of pupillary dilation or constriction could not be detected.

CLINICOPATHOLOGIC FINDINGS

Erythrocyte counts, total leukocyte counts, hemoglobin levels, packed cell volumes, and differential leukocyte counts were all within normal limits. Serum calcium, magnesium, and phosphorus levels were within normal limits for range sheep in this area.

Most of the sheep examined had mild proteinuria, moderate ketonuria, and urine pH of five or lower.

Erythrocytic cholinesterase activity levels as measured by the delta pH method (Michel test) were severely depressed, ranging from 0.00 to 0.15. Cholinesterase activity levels determined at the same time for a group of normal sheep ranged from 0.20 to 0.25.

Cattle and horses grazing in the same general area with the affected sheep had depressed cholinesterase activity, but dogs and people in this area did not. Cattle, horses, sheep, and people north of the area described previously did not have cholinesterase depression.

PATHOLOGIC FINDINGS

Complete necropsies of 16 of the affected sheep failed to reveal any consistent lesions. One sheep had mild scarring of the kidneys, and several had abscesses in the lungs or mediastinal lymph nodes. *Corynebacterium ovis* was isolated from the abscesses. The mesentery in several sheep was congested.

Evidence of inflammation or degeneration of the central nervous system, peripheral nervous system, or skeletal musculature was not found on histologic examination. There was nonsuppurative inflammation and sarcosporidiosis in the myocardium. A variety of chronic pulmonary lesions were observed. The portal areas of the liver were infiltrated by mononuclear cells, the severity of which varied from sheep to sheep. Lesions ranging from mild glomerulitis to mild diffuse interstitial nephritis were found in the kidneys. Lesions of significance which would have resulted in the death of the sheep were not found.

Attempts to isolate bacteria or viruses or to demonstrate toxins as the causative agents of the disease were not successful. Therapy with parenteral solutions of potassium, calcium, phosphorus, and glucose did not benefit the ill animals.

TABLE 2.—FORAGE FEEDING EXPERIMENTS

Plant	Number of animals fed	Amount of plant per day		Average cholinesterase activity prior to experimental feeding	Average cholinesterase activity during 2-day intervals at feeding					Signs of disease
		Pounds	Kilograms		(a)	(b)	(c)	(d)	(e)	
White rock black sage	3	2	0.9	0.14	0.13	0.06	0.08	0.02	0.01	Salivation.
Control black sage	3	2	.9	.10	.09	.13	.19	.12	.11	
White rock bud sage	3	2	.9	.17	.07	.07	.10	.03	.02	Salivation, muscular twitching, torticollis.
Control bud sage	3	2	.9	.16	.11	.13	.18	.10	.06	
White rock shad scale	3	2	.9	.15	.07	0	.02	.03	.04	Salivation, muscular twitching.
Control shad scale	3	2	.9	.14	.13	.06	.10	.10	.13	
White rock cheat (June) grass.	3	3	1.3	.20	.04	.03	0	.03	------	Severe neuromuscular disorders (1 died).
Control cheat (June) grass.	1	3	1.3	.12	.23	.17	.17	.20	------	

RELATED FACTORS

On March 21, the U.S. Army reported that two different nerve agents designed for chemical warfare had been released in three separate tests at the Dugway Proving Ground on March 13, 1968 (the day prior to the onset of illness in the sheep). A nonpersistent agent had been released from 155-mm. ammunition, and a persistent agent had been burned and sprayed from low-flying, high-performance aircraft. These tests were routine operations at the proving ground and had been conducted many times previously. The nerve agents contained organic phosphate-like compounds that inhibit the activity of cholinesterase.

The nerve agents were released at various proving-ground sites approximately 40 miles from the point where the last band of sheep was affected. Some of the agent released from the aircraft was carried to an elevation higher than that at which the material was usually released. Approximately 1 hour and 25 minutes after the completion of the spraying test, a frontal passage occurred with a shift of wind direction. Considering wind speed and direction, these winds could have made it possible for the contents of an air mass, present on the aerial test site, to have been carried over the affected areas. Light snow and rain showers were recorded intermittently during the evening after the test and on the following morning.

EXPERIMENTAL REPRODUCTION OF THE CLINICAL SIGNS

On April 1, 1968, forage plants from the various areas where the sheep became ill were collected. Black sage, shad scale, bud sage, and cheat grass had been extensively grazed by the affected sheep. These plants were gathered in the area where bands one and two were affected. The same species of plants were collected from the northern end of Skull Valley, where no sheep had been ill, to be used as control material.

The plants were dried and ground, and amounts approximating normal consumption were fed to sheep via stomach tube or rumen fistula. The results of the 10-day feeding trial are recorded (table 2).

All sheep fed forage from the area where the sheep died had a marked depression of the erythrocytic cholinesterase levels. Sheep fed bud sage and cheat grass developed clinical signs identical to those seen in the sheep in Skull Valley. One of the sheep being fed cheat grass died 5 days after the experiment began with severe neuromuscular disorders, accompanied by complete inhibition of erythrocytic cholinesterase activity. Changes were not observed in sheep fed the control forage.

The experimental sheep fed forage collected in Skull Valley salivated profusely and had trouble breathing. These signs were transitory and preceded clinical signs that were typical of Skull Valley disease.

Experimental sheep at the Dugway Proving Grounds developed signs identical to those observed in the sheep in Skull Valley, after they were given repeated feedings of low levels of one of the nerve agents used in the March 13 tests. Single feedings of high dosages of the same agent rapidly killed sheep. Animals given low levels of the test agent responded temporarily to treatment with atropine and pralidoxime chloride, but later reverted to their original condition.

AREA CONTAMINATION

Sheep in three different groups of five, placed in the White Rock area (where band one was affected) on March 19, April 1, and April 4, respectively, became affected with an illness identical to that of the sheep initially affected. In the first group, all five sheep were affected; in the second, four of the five (the fifth could not be found) were affected; in the third group, one of the five was affected (four of the five sheep could not be found). The fate of the lost sheep was not determined. Signs occurred as early as 6 days after the sheep were allowed to graze in the area. Two of these groups had normal cholinesterase activity prior to their placement on the range; the third group was not examined. After the onset of the clinical signs, cholinesterase activity of the affected sheep in all three groups plummeted to near zero.

A fourth group of sheep (five head) was released into the White Rock area on April 9. These sheep were muzzled but were allowed to roam over the same general area as the sheep in the first three groups. Each evening, the sheep were returned to a small corral, which had been cleared of natural forage, and fed hay and water brought in from outside the affected zone. After 10 days of roaming in the area, these sheep appeared to be normal, and changes in erythrocytic cholinesterase levels could not be detected.

DETECTION AND IDENTIFICATION OF A NERVE AGENT

Since the chemical formulas of the nerve agents involved in the testing program at the Dugway Proving Grounds are confidential military information, detection of the agent required the close cooperation of various investigating agencies. The National Communicable Disease Center, National Animal Disease Laboratory, Utah Public Health Pesticides Laboratory, Edgewood Arsenal, and the chemical division at the Dugway Proving Grounds all contributed valuable time, personnel, and facilities toward the ultimate identification. The National Communicable Disease Center has reported that one of the nerve agents was detected and identified in the cheat grass used in the experimental feeding to induce the disease.

DISCUSSION

The peculiarity of the Skull Valley event was compounded by a variety of factors. Because of the extremely large number of sheep affected by this unknown disease initially, animal health regulations demanded that a specific diagnosis be made. The risk to man and other animals in the area could not be evaluated until a diagnosis was made. It was felt that any agent capable of killing large numbers of sheep in a short time could cause human fatalities. It was, therefore, important to not only identify the agent, but to determine how it reached the sheep and why no other species had been affected.

Preliminary investigations indicated that the disease was not infectious, but that it was a chemical intoxication primarily affecting the nervous system of the sheep. Organophosphate poisoning was suspected, but the source could not be identified. Sheep did not have typical clinical signs of organophosphate poisoning, that is, salivation, pulmonary edema, and impaired respiration. Treatment with atropine was not effective. Fourteen days after the initial onset of the disease, the sheep that were recumbent but alive were killed and buried along with those that had died.

Because of the confidential nature of the testing performed and test agents used at the Dugway Proving Grounds, valuable time passed before the release of the nerve agent on March 13 and the onset of the disease in sheep on March 14 were correlated. Once this was achieved, many of the bits of information collected in the interval began to fit into place.

Although poisoning by plants known to be toxic was ruled out early in the investigation, four factors indicated that the intoxication was forage-related: (1) the suckling lambs in band five did not have signs of the illness although their dams were severely affected; (2) sheep in a band held about one-half mile from

band three were not affected (these were being maintained on hay and did not have any appreciable natural forage available to them); (3) muzzled sheep, allowed to roam the described area, did not contract the clinical disease; and (4) sheep outside Skull Valley but fed forage from the affected area became ill with clinically similar signs: It has been postulated that during the spraying of the nerve agent from the low-flying aircraft some of the material was carried aloft. The wind, blowing from the south at the time of the spraying, could have carried the material northward, except that soon after the test, the frontal passage occurred, with a change in wind direction which may have carried the material over Skull Valley. Precipitation which fell on the evening of March 13 could have washed the nerve agent from the air and deposited it on the forage.

Accidental contamination of forage or livestock with commercial pesticides sprayed from low-flying aircraft is not unusual. Damage has occurred as much as 60 miles from the place where the spray was applied.

Cattle and horses within the contaminated area had depressed levels of erythrocytic cholinesterase activity but did not have clinical signs of the disease. The grazing habits of these animals may account in part for their apparent lessened susceptibility to the nerve agent; however, cholinesterase enzymes present in the serum of cattle and horses but victually absent from the serum of sheep may have buffered the effect of the organophosphate on the nervous system of the cattle and horses.

It is not known if contamination was only on the surface of the plants (as would be expected if fallout from the March 13 test was alone responsible), if the agent was present in the tissues of the plants (as is known to occur with some organophosphorous insecticides), or if both the plant surfaces and tissues were contaminated. Tissue contamination is a real possibility since agents had been tested many times over a period of years, and the prevailing winds are from west to east. If plants in the area had stored toxic organophosphate compounds, it is possible that sheep grazing that part of Skull Valley were already exposed to a continuous low-level dosage and that the test of March 13 provided the extra dose required to cause overt disease. This additional insult was not sufficient to affect other animals in the area that had not eaten the same feeds.

In the experimental reproduction of the disease, impaired respiration and salivation were prominent although transitory signs of poisoning. The clinical signs described earlier persisted. Because of the interval between the initial onset of the disease and the time that veterinary assistance was sought, the signs of salivation and respiratory difficulty in the sheep (in Skull Valley) probably passed unnoticed.

The onset of clinical signs of Skull Valley disease in normal sheep introduced into the White Rock area between March 19 and April 4, 1968, indicated that the forage was still contaminated.

Feeding trials using forage collected June 10 and August 10, 1968, did not result in the appearance of clinical signs or cholinesterase depression in sheep.

Agricultural Research Service Report on Sheep Losses in Utah During March 1968

Numerous persons and agencies participated in the investigation of this incident. These included:

Agricultural Research Service, USDA:
- Poisonous Plant Research Laboratory, Animal Disease and Parasite Research Division, Logan, Utah.
- National Animal Disease Laboratory, Animal Health Division, Ames, Iowa.
- Animal Health Division field force, State of Utah.

National Communicable Disease Center, PHS, HEW, Atlanta, Ga.
Bureau of Land Management, Department of the Interior.
Department of Animal Science, University of California.
Department of Ecology and Epizoology, University of Utah.
Iowa State University Veterinary Diagnostic Laboratory.
Food and Drug Administration, HEW.
Dugway Proving Ground, U.S. Army.
Edgewood Arsenal, U.S. Army.
Utah State Public Health Department.
Utah State University.
Utah Wool Growers Association.
A veterinary practitioner.

A strange illness, first noticed on the evening of March 14, 1968, occurred in two bands of sheep on a ranch in Skull Valley, Utah. The herder described the sheep as "crazy in the head." Many of the sheep were dead the next morning. During the next few days, essentially 100 percent of the 5,600 sheep in these two bands developed the disease. Approximately 4,300 of these sheep died or were destroyed. On March 17 and 18, signs of the illness were noted in three other flocks of sheep in Skull Valley. Most of the 630 sheep in these flocks were affected with about 150 of them eventually dying or being destroyed. On March 20, a few sheep in a band located in Rush Valley, the valley just east of Skull Valley, developed signs identical to those noted in the first five bands.

Skull Valley is located approximately 60 miles southwest of Salt Lake City. It is a desert valley lying between the Cedar and Stansbury Mountain Ranges. Dugway Proving Ground, an Army chemical and biological warfare center, is located in the valley. Ranch lands border the proving ground on the north and east.

All affected sheep were in a fairly well-defined area extending east-northeast from a Dugway test site where gases are tested. The area was somewhat triangular shaped, about 50 miles long, and 20 miles wide with the apex of the triangle extending from the test site. The highest morbidity and mortality was in flocks closest to the test site. Cattle, horses, dogs, and humans in the same general area as the ill sheep did not show clinical signs of the disease. On a survey, 15 dead rabbits, other rodents, and birds were found. One jack rabbit was observed to show signs of incoordination and trembling. No illness was found in sheep outside of the affected area.

One band of sheep located between two of the affected bands did not show signs of the disease. These sheep were being maintained on alfalfa hay.

The area was examined for poisonous plants. Although halogeton was found where one affected band was located, it was not growing in other areas of sick sheep. The only arthropods found on sheep were sheep keds. The affected bands of sheep did not obtain water from a common source nor were they eating similar food. The owner advised that no pesticides had been sprayed on the range where the affected sheep were located.

The clinical signs shown were similar in all affected groups of sheep but less severe in those farthest from the test site. The general signs suggested an involvement of the central nervous system. Animals of all ages were affected, and the large number of affected animals were involved nearly simultaneously. The most characteristic sign was marked weakness of the cervical musculature which resulted in flexion of the neck so that the head was carried with the nose tucked down to the sternum. Most of the sheep had profuse, tenacious nasal discharge. Many sheep were down and unable to rise. Sheep which were able to rise made frequent attempts to urinate. Body temperatures of the affected sheep were normal. The course of the disease was as short as 24 hours or as long as several weeks in those which died.

Autopsies were performed on several sheep and numerous tissues were collected for laboratory studies. No lesions considered significant were seen. Urine pH was 5 or lower, more acid than normal. Cholinesterase activity levels were severely depressed. Cattle and horses in the affected area also demonstrated depressed cholinesterase activity. Dogs and humans in the affected area had normal levels. Cattle, horses, sheep, and humans outside of the area did not have cholinesterase depression. In addition to the animal tissue, many other samples were collected including water, snow, soil, rocks, and vegetation.

It was reported that a nerve agent designed for chemical warfare had been released at Dugway Proving Ground on March 13, the day prior to the outbreak of the illness in the sheep. The agent was released as part of a routine test conducted at the proving ground. These tests have been conducted at the proving ground for several years. The nerve agents released were organic phosphate type compounds which cause severe cholinesterase depression.

Attempts to isolate a viral or a bacterial agent from affected sheep were unsuccessful.

Laboratory tests conducted at the National Animal Disease Laboratory in Ames, Iowa, indicated that there were materials present in the snow water which would produce a reduction in cholinesterase activity. Tests did not indicate the presence of chlorinated hydrocarbons, heavy metals, oxalates, alkaloids, or nitrates in abnormal amounts. Other tests conducted at NADL, designed to demonstrate a possible relationship between substances in the tissues of the

31-509—69——6

affected sheep and the test agent (supplied to NADL by Dugway Proving Ground), were inconclusive. However, it is understood from reports from the Public Health Service, National Communicable Disease Center, that water and forage at Skull Valley as well as blood and liver from ill sheep showed an agent which proved to be identical in chemical composition to a sample of test agent supplied by Dugway.

At the Poisonous Plant Research Laboratory at Logan, Utah, forage plants from the areas where the affected sheep were located and the same plants from areas where sheep were not affected were fed to sheep. All sheep fed forage from the area where the sheep died had a marked depression of cholinesterase activity. The cholinesterase activity level in sheep fed forage from unaffected areas remained normal. Moreover, some of the sheep fed forage from the affected area developed clinical signs identical to those seen in the sheep that were affected in Skull Valley. Experimental sheep at the Dugway Proving Ground developed identical signs to those observed in sheep in the affected area of Skull Valley after they were fed low levels of one of the nerve agents.

Three different groups of normal sheep were placed in the affected area on March 19, April 1, and April 4. All groups developed illness identical to that of the sheep in the initial outbreak. Cholinesterase activity of sheep in all of the groups was severely depressed. A fourth group of sheep was released into the area on April 9. These sheep were muzzled to prevent them from eating natural forage. Each night, they were corralled and fed hay and water which was brought in from an area outside of the affected area. After 10 days of roaming the area, the sheep were normal, and there was no change in the cholinesterase activity level.

On June 5, 1968, 127 head of adult sheep and 86 lambs were delivered to the Poisonous Plant Research Laboratory, Logan, Utah, by the U.S. Army, Dugway Proving Ground. Three different groups of sheep were involved. Group one consisted of 79 head of sheep affected in the March 14 outbreak and their lambs. Group 2 was comprised of 38 ewes treated with the Dugway nerve agent, and group 3 was composed of 10 normal sheep that had served as controls.

Blood samples were taken from sheep at random in groups 1 and 2 and from the lambs in group 1 at two intervals. Cholinesterase activity levels were as follows:

Normal values	0.15 to 0.30
Group 1	0.08 to 0.16
Group 2	0.10 to 0.19
Lambs from group 1	0.12 to 0.21

Some animals were still affected with severe neuromuscular incoordination.

On June 13, 1968, eight mature beagle dogs were purchased. Following the drawing of blood samples to establish normal cholinesterase activity levels, the dogs were divided into two groups. Since July 14, one group has been maintained on a diet of 1 pound raw mutton per dog per day, and the second group on the same amount of raw lamb. The mutton and lamb were obtained from sheep affected in the March 14 exposure (sheep group 1). Weekly determinations of cholinesterase levels have not revealed any significant deviation in cholinesterase activity of either group. The dogs have remained bright, alert, and in good health.

Forage was gathered from the affected area on June 12, 1968. This material was fed to six sheep at the Logan Laboratory at the rate of 2 pounds per day per animal for a period of 10 days. Cholinesterase activity was determined every other day. No significant changes were noted in any of the sheep.

An unqualified conclusion as the cause of the sheep deaths is difficult. Circumstantial evidence points toward a nerve agent tested at Dugway. There is no evidence to suggest that viral or bacterial disease, poisonous plants, insecticides, or feeding or management procedures were involved.

Reports to ARS from various sources indicate there were about 7,900 sheep in affected bands with approximately 6,300 sheep affected with a mortality, including those destroyed, of approximately 4,450.

Mr. REUSS. Thank you very much, Dr. Van Kampen.

Gentlemen, the noon hour has approached. We have now had an opportunity to hear your statements. If agreeable, I will ask you to come back at 2 o'clock and we will undertake our questioning.

The subcommittee will stand in adjournment until 2 o'clock this afternoon.

(Whereupon, the proceedings in the above-entitled matter were adjourned at 12:15 p.m., to reconvene at 2 p.m. of the same day.)

AFTERNOON SESSION

Mr. REUSS. The Subcommittee on Conservation and Natural Resources will be in order for a continued hearing on possible poisoning of the environment by the U.S. Government.

We had statements from the witnesses at the panel table. The subcommittee will now address some questions to them.

Dr. Davis or Dr. Sidel, or both, from the evidence of the sheep-kill at Dugway, what sort of dose of VX is necessary to kill a sheep?

May I say, before you answer that, while members of the committee will probably address their questions to individual members of the panel, all members of the panel are invited to volunteer answers if they have anything to add to what has been said.

Dr. DAVIS. The NCDC report states that the LD–50 (the dose lethal for 50 percent of the sheep exposed) through the skin—is 1.2 milligrams for a 40-kilogram sheep. Apparently these sheep were exposed to organophosphates via the oral route as well. One wonders if there was a cumulative effect with earlier organophosphate exposure and progressive depression of cholinesterase.

Apparently some of the sheep didn't die until several days after exposure. The doses found in the residues killed them in 5 days, so I would assume the doses were relatively low.

Mr. REUSS. Like what, in terms of milligrams?

Dr. DAVIS. I couldn't tell you that. I don't know what concentrations of the VX were. Certainly they were less than 1.2 milligrams.

Mr. REUSS. Do any of you gentlemen have information on this?

Dr. OSGUTHORPE. This is classified information and we cannot divulge it.

Mr. REUSS. With the agreement of the minority I suggest we clear the hearing room and proceed on a classified basis.

Will the clerk clear the hearing room, for just this question and its answers, of all except members and staff of the subcommittee and Dr. Osguthorpe. We will ask you all back in just a few minutes.

(Discussion off the record.)

Mr. REUSS. We will be back on the record now.

Have each of you gentlemen at the witness table had an opportunity to examine the Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground, Department of the Army, November 1968?

The witnesses indicate that all have examined the report.

I want to take up some of the recommendations of that report with you gentlemen to assess their effectiveness.

If you will refer to page 2, page 2 contains certain general recommendations. In those recommendations it is said that testing of persistent lethal agents in quantities not to exceed the equivalent of one artillery round, rocket, or mine can be resumed without any change in present test practices. As to testing of persistent lethal agents in larger quantities than that, certain restrictions are set up.

Now let me ask Mr. Williams a question based on his testimony. I gathered from your meteorological testimony, Mr. Williams, that whereas for a short period in the fall of the year meterological conditions at Dugway are such that it is possible to predict wind and weather with reasonable confidence, that at other times of the year, particularly in the late winter and spring, the meteorology is such that no confident prediction can be made.

Is that a fair statement of your testimony?

Mr. WILLIAMS. I wouldn't say the last is fair. It is less often that we can make confident predictions in late winter and spring when the weather is generally stormy but I wouldn't say no confidence can be put into the forecast. Just a lesser degree of confidence.

Mr. REUSS. In layman's language, do you mean that at times other than in the fall of the year a weatherman like yourself who predicts that nothing higher than a 15-mile-an-hour wind is to be expected, may be proved wrong by events?

Mr. WILLIAMS. Well, during the winter, partciularly late winter and spring, there are a lot of cold fronts moving into the area. There is a rapid change in air mass from a warm southerly flow with a sharp shift of wind to a northwesterly flow and much colder. These fronts move fairly rapidly in the winter and spring, accompanied by very strong winds. Winds ahead of these fronts may reach 30 to 40 miles an hour. After the wind shift it may be briefly 30 or 40 miles an hour and drop down rapidly to 10 or 15 miles an hour after this.

The timing of these fronts is difficult to predict. You can't say 24 hours ahead this will go by at 3 o'clock tomorrow afternoon. It may be noontime or 6 p.m.

That is the state of the art—more or less in this range of several hours as to exact timing of the passage of the front—if you talk about a forecast 18 or 24 hours ahead.

Mr. REUSS. Your remarks just now have been addressed to the situation in the cold front season of late winter and early spring.

What meterological conditions are there in the late spring and summer, if any, which make forecasting less accurate than it can be in the fall?

Mr. WILLIAMS. Well, in the late spring, as I mentioned—all of spring, in fact—high-level, low-pressure systems develop. A low-pressure system will develop 15,000 to 20,000 feet or higher in the atmosphere. These are difficult to predict.

Our numerical prediction models are getting better on this. Our computer models from the National Center at Suitland are improving and we hope to handle these better in the future. They are still difficult to predict any length of time ahead. These lows are accompanied by widespread rain or snow, and general precipitation over the area. Not just showers over the mountains but rain and steady snow over the valleys as well.

During summer we have thunderstorms. We can tell fairly well on a day when thunderstorms are apt to break out over the area. The air is then unstable. But you cannot pinpoint the exact location of the individual thunderstorm cells which cover only an area of a few square miles. This is difficult to predict, their actual pinpoint location and movement in the next few hours.

Mr. REUSS. Can you predict their existence at all?

Mr. WILLIAMS. That the general area will have showers, yes; this is fairly well done, but the actual location of the thunderstorms themselves covers only a limited area and it is difficult to do.

Mr. REUSS. Dr. Osguthorpe and Dr. Van Kampen, I would like to ask you both about such evidence as you have been able to gather through your own observations concerning the persistency of VX agents. Dr. Osguthorpe first.

Dr. OSGUTHORPE. Well, Mr. Reuss, I think it persisted a lot longer than the 4 days that we were assured by the Army it persisted because these sheep—new sheep that were introduced into the area weeks later still had—after 4 or 5 days still showed clinical symptoms of organic phosphate poisoning and their cholinesterase levels were depressed.

Mr. REUSS. Dr. Van Kampen, is it not a fact that almost a month after the spraying of the Dugway area with VX gas on March 13, 1968, a sheep which had been fed vegetation from the spray area died with symptoms resembling that of VX poisoning and a considerable number of other sheep, while they didn't die, displayed a cholinesterase—is that the word—cholinesterase deficiency consistency with VX poisoning?

Dr. VAN KAMPEN. Consistent with organic phosphate poisoning. One animal died the night of April 9, or early in the morning of April 10, and the other animals that were fed vegetation during that period—again material collected on April 1—did show marked cholinesterase depression.

Mr. REUSS. There is no doubt in your mind that this was due to the unfortunate accident of March 13, is there, Dr. Van Kampen?

Dr. VAN KAMPEN. No, Mr. Reuss.

Mr. REUSS. Your answer was no?

Dr. VAN KAMPEN. Yes; my answer was "No."

Mr. REUSS. Any doubt in your mind?

Dr. OSGUTHORPE. No.

Mr. REUSS. That indicates, then, Dr. Osguthorpe and Dr. Van Kampen, that the persistent lethal effect of VX is at least a month, does it not?

Dr. VAN KAMPEN. Correct.

Mr. REUSS. Would you agree, Dr. Osguthorpe?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. Now in the light of that, I direct the attention of members of the panel to the recommendation of the Army's advisory committee that VX testing in the atmosphere be continued, despite the incident of March 1968, provided that the cloud containing the VX gas does not cross U.S. Highway 40 for at least 3 hours.

Consider that in connection with the testimony that U.S. 40 is a widely traveled interstate highway.

My question is: In view of the plain physical fact that VX retained its ability to kill for at least 3 weeks or a month, as evidenced by the second sheep incident, is it good practice in your judgment to expose travelers on U.S. Highway 40 to a lethal cloud that is only 3 hours old? Dr. Davis?

Dr. DAVIS. As I said in my testimony, I believe either the road should be closed or the gas should not be permitted to cross Highway 40. The obvious extension of that is that the testing should be stopped.

From the evidence presented thus far I believe the gas at Highway 40 would be toxic to individuals located there.

Mr. REUSS. What do you suppose the Pentagon had in mind by this rather curious rule? It would seem to me that they were under the impression that VX lost its killing power after 3 hours.

Am I overlooking something?

Dr. DAVIS. I and my associates cannot understand the rationale for this because the evidence as presented here and the recommendations both imply that VX is a persistent gas and certainly lasts more than 3 hours. I wonder if that 3 hours is derived from a distance of 30 miles from the test site divided by maximum permissible winds of 10 miles per hour. That has nothing to do with the known persistence and lethality of this gas. I don't understand how a statement like that could be made with the facts we have here.

Mr. REUSS. Taken in conjunction with the other admonition of the Pentagon that the release heights be no greater than 300 feet, wouldn't the lethal cloud be concentrated where it will hit motorists as they cross the highway if the wind happens to be in that direction?

Dr. DAVIS. I would think so.

The other problem is we know the smaller particles tend to rise. That means they would be blown farther and precipitate later. Larger particles would drop earlier.

Speaking to Dr. Pallmann on the phone, he mentioned that if an aerosol is released close to the ground in the presence of turbulence it still may be distributed 30 miles. It is not a question necessarily of how close to the ground it is released. It is a combination of turbulence, weather, many other factors.

Mr. REUSS. Dr. Osguthorpe, are you acquainted with Sheriff Gillette of Tooele County?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. Do you happen to know whether he has even been asked to close off Highway 40 to avert danger to motorists on it?

Dr. OSGUTHORPE. Yes; he has.

Mr. REUSS. Before or after March 13, 1968?

Dr. OSGUTHORPE. Prior to March 13, 1968.

Mr. REUSS. Do you recall when those occasions were?

Dr. OSGUTHORPE. No; I don't.

Mr. REUSS. You don't know how long prior to March 13, 1968?

Dr. OSGUTHORPE. No.

Mr. REUSS. Do you know whether Sheriff Gillette did in fact close off Highway U.S. 40?

Dr. OSGUTHORPE. Yes; he did.

Mr. REUSS. Dr. Davis?

Dr. DAVIS. In "Military Medicine" in 1964, there is a description of a simple and inexpensive field anticholinesterase detector, either a badge of some sort of small plastic device. We had wondered if any of these devices had been in use—particularly for Highway 40, or for that matter, at any area in the periphery of the proving ground—to detect the presence of gas or other particles which might have been dispersed. I don't know if these detectors have actually been adapted for field use.

Mr. REUSS. Can you give us the citation?

Dr. DAVIS. In my bibliography, No. 33.

(The citation referred to is Zachs, S.I., Blumberg, J. M. "Simple and Inexpensive Anti-Cholinosterase Detectors for Field Use," *Military Medicine*, 129; 1084–1086, 1964.)

Mr. REUSS. Thank you.

Dr. DAVIS. Apparently a red dye had been mixed with this gas. Yet the aerosol droplets had been so dispersed that the dye could not be determined on the snow. Our chemists say it is quite possible that one could extract this red dye from the snow with an ether solution. This would have shown that the aerosol had been present in the snow some distance way.

Mr. REUSS. Thank you, Dr. Davis.

Let me turn to another element of the Army report, page 25, 4a, and I will read a couple of sentences:

"4. Two new factors must be introduced into the weather forecast as a consequence of the deaths of the sheep in March 1968. a. Whereas concern was formerly restricted to a few miles from the release, it must now be extended to several tens of miles. This enlargement considerably increases the forecast difficulties for the meteorologist. It highlights the need to predict meso-scale weather systems whose dimensions lie between 1 and about 50 miles. * * *"

Mr. Williams, in your judgment, is concern with the ambient weather for only 50 miles consistent with safety to human beings and animals?

Mr. WILLIAMS. As I noted, I think this should be extended to include the synoptic scale, the range of weather events that have dimensions of say 50 to several hundred miles.

Mr. REUSS. 300 miles?

Mr. WILLIAMS. Up to 300 or so. These cold fronts that come through sometimes move 40 miles an hour. You can see that in a matter of 3 to 5 hours this front would move a couple hundred miles and I would think you would want to be concerned with a synoptic feature of this scale.

Mr. REUSS. Therefore, a weather forecasting system which concerns itself with only the innermost 50 miles may produce a go-ahead signal for a VX test, but a cold front 100 miles away, let us say, could be upon the release ground within a couple of hours and transport the released nerve gas was over a wide area and with lethal effect; is that right?

Mr. WILLIAMS. Certainly the cold front would be there in 2 or 3 hours. The exact effect on the nerve gas I am not positive about.

Mr. REUSS. As far as the dissemination of the gas, benign or malignant, whatever it is, a meteorological regimen which confined itself to 50 miles would be unsuccessful; would it not?

Mr. WILLIAMS. I think it would be too small a scale; yes.

Mr. REUSS. Let me turn to another recommendation of the Pentagon committee.

On page 3, recommendation B–1 discusses the need for more knowledge of toxicity and says: ". . . Much of this information is already known. However, to insure that all essential knowledge gaps are filled, immediate steps should be taken to obtain necessary toxicological information on all chemical agents tested."

Dr. Davis, do you believe that outside testing in the atmosphere of chemical agents should be conducted before the necessary toxicological information has been obtained?

Dr. DAVIS. No, sir.

Mr. REUSS. You disagree with the Army's recommendation in this particular——

Dr. DAVIS. That outside testing should take place before the facts are known——

Mr. REUSS. The Army is apparently going ahead with its testing of chemical agents before knowing their toxicity.

Dr. DAVIS. This is the issue we raised. There was a report in November 1968 and apparently testimony today said testing began in December 1968. Yet apparently the answer to these questions regarding the known toxicity and persistence haven't been disseminated to the scientific community and are not yet known. Until they are known we believe there shouldn't be any further testing. The risks of testing must be balanced against the benefits.

If the community says it is worth testing because of benefits yet to be described, this is a decision we must make. From a scientific point of view, there are still the unknown answers we recognize here.

Personally, I believe the testing isn't worth it.

Mr. REUSS. Let me refer you now to page 2 of the report, recommendation A2b:

> Testing of persistent lethal agents and munitions in quantities of agent not to exceed the equivalent of one artillery round, rocket, or mine be resumed without modification of current practices and safety procedures * * *."

This could include testing of lethal agents with as large a quantity as that contained in a 155-millimeter artillery round. Would you gather that, Dr. Van Kampen?

Dr. VAN KAMPEN. Yes, sir.

Mr. REUSS. In your judgment, is the amount of persistent lethal agent or nerve gas contained in a 155-millimeter artillery round of so small and insignificant a nature that no modification of the practices that prevailed at the time of the Dugway sheep kill on March 13, 1968, are necessary?

Dr. VAN KAMPEN. I am not familiar with exactly what happens when the artillery round bursts so I don't think I am qualified to answer that question.

Mr. REUSS. If you were told that those artillery rounds were detonated at a height of 50 feet above the ground at the target area, would you say that the procedures that were in effect at the time of the Dugway sheep-kill on March 13, 1968, are adequate procedures to protect the public in its environment?

Dr. VAN KAMPEN. I would say, yes.

Mr. REUSS. Any other comments on that point from members of the panel?

Mr. Vander Jagt?

Mr. VANDER JAGT. Dr. Davis, did I understand correctly that the scientific community does not know how persistent VX is?

Dr. DAVIS. As far as I am able to find out, we have no data on persistence of VX.

Mr. VANDER JAGT. Do you know whether or not the Army has that data?

Dr. DAVIS. No, sir. That is one of the problems. They won't tell us.

Mr. VANDER JAGT. You don't know whether it's a case that the Army doesn't know either, or that it knows and won't release it.

Dr. DAVIS. I have no idea what their information is.

Dr. SIDEL. I would like to comment on persistence. That word is being used two different ways. First, persistence of the chemical molecule is determined by how long a period is required for it to be destroyed or degraded or broken down to another chemical. The other meaning of persistence is the period of time a sufficient quantity of the material—that is, a sufficient number of molecules—remain together in a dose which will cause harm to human beings or animals.

I think there is now quite sufficient evidence from around the table as well as in the published literature that this molecule lasts for a very long time indeed. Whether this material in an aerosol spray remains together in a droplet form for a long enough period of time to cause damage at some point later in time is the question at issue, I believe. It is this kind of information which is quite unobtainable. Even with the information obtainable, the persistence might still be very different, depending on other kinds of conditions or the kind of aerosol spray used, so even any single fact about persistence of a given kind of spray would not tell you about its persistence under other kinds of conditions.

Mr. VANDER JAGT. Because we are dealing in an area of the unknown to some extent this may be difficult to answer.

One could get the impression that this tragedy of the sheep at Dugway was solely because of the malfunctioning of the spraying of the gas that continued to spray after it was intended to be cut off. Do either of you have any opinion as to whether we might have had the tragedy, because of the existing weather conditions at the time, even if there hadn't been a malfunction in the turning off of the emission of the spray? Can either of you comment on that?

Dr. SIDEL. I think there is only one thing one might venture to predict: Using such material over a long enough period of time a disaster would have occurred. Whether in 1969 or 1970 or 1971 is impossible to predict. If you keeping using material of this kind, you are going to get hurt by it.

Dr. DAVIS. I think this is true. It is a series of events. We have seen (1) malfunction; (2) inadequate weather forecasting; and (3) no apparent means of detecting chemicals beyond the confines of the proving ground. It is quite possible that there had been previous leaks but it wasn't until 6,000 sheep died that we addressed our attention to the problem. So it is not just one malfunction. It is a series of events which add up until some disaster happens.

We can't wait for another combination of all these events. There aren't any guarantees that the next disaster won't be worse. This material is so toxic we can't take a chance.

Mr. VANDER JAGT. Would you please correct me if my impression is incorrect? We cannot say that it was the malfunction, the mechanical malfunction and that alone which caused this specific tragedy, but rather it was probably a combination of factors, one of which was the mechanical malfunction.

Dr. SIDEL. It seems from the testimony which has reached the open literature that the specific cause of this disaster was a mechanical mal-

function in a pressurized tank together with the meteorological conditions which took place on that day. However, if I may suggest it, the real reason for the disaster was neither the malfunction nor the meteorologic conditions but the fact there was a plane up there spraying nerve gas around.

Mr. VANDER JAGT. Dr. Davis, you inferred, continuing in the way that we continued in the past, because of the possibility of a combination of factors, that this exposes us to a tremendous danger. I wonder if you could give me a little better indication of what you mean by "tremendous danger." The death of one single 6-year-old child would indicate to me a tremendous danger. I don't know if you are talking about one person or ten million or one million people.

Dr. DAVIS. Theoretically the question was answered last week at Congressman Gallagher's hearing dealing with the transportation of the nerve gases—how many people could be killed from a rupture of one tank. A figure was thrown out of 100,000 people. That is a good figure to talk about and that means if all these people were in close space and there was optimal dispersion of the gas. We have a situation where there are apparently thousands of tons of this lethal agent distributed around the country in secrecy. There are statements made regarding how exposed individuals are to be treated. Yet I don't know if any of the medicines or the materials or the medical help is available.

In our testimony on the transportation incident we pointed out that accidents do occur, and occur with increasing frequency. This material is of such toxicity that one accident can result in great danger. For example, what if it was the nerve gas instead of 40 millimeter rockets spread outside of Los Angeles on May 15 when an ammunition train had a hot box on the car. Well, that is a horrendous disaster. I don't know how we could deal with it.

Apparently these liquids are being shipped around the country and we have more than enough material theoretically than we can ever use. It would appear that the danger to the population here from an accident may be greater than the use of the material by somebody else on our population. One accident could be disastrous.

Mr. VANDER JAGT. With regards to the open air testing at Dugway, how many miles away is Salt Lake City?

Dr. DAVIS. Eighty miles.

Mr. VANDER JAGT. Is there any combination of circumstances where the population there could be exposed to danger.

Dr. DAVIS. It would appear so. With the unpredictability of the winds.

As I said before, I don't know if there are detection devices off base. I don't know how far the aerosol can spray from the onsite test. If one will test nerve agents or any agent which can affect the environment one should have data from aerosols with nontoxic agents under many conditions at different heights to get an idea what can happen at virtually any condition.

Dr. SIDEL. I would only comment that if an accident could happen so that sheep are killed 35 miles away, there is very little confidence that an accident can't happen to kill people 80 miles away.

Mr. VANDER JAGT. Much of this, I think, probably involves the predictability of weather.

Mr. Williams, as a former television weather forecaster, I am vividly and painfully aware of the unpredictability of weather. I believe you told us you were familiar with the ad hoc committee's recommendations?

Mr. WILLIAMS. That is right.

Mr. VANDER JAGT. Then you can correct me if my assumptions were wrong. I think in one instance they asked, for example, that we know that the wind wouldn't be more than 15 miles an hour and that we know that there won't be thundershowers within 100 miles for a period of 8 hours. Are you satisfied that we can make a prediction of that nature with a great degree of certainty?

Mr. WILLIAMS. There are certain days in the year on which you could make predictions of this nature. If you are in the middle of a large high pressure system and the air mass is dry and stable you know very well there will be no thunderstorms within a hundred miles of Dugway, for example. There are many other days when you can't say this. With a moderate amount of moisture, a variable amount, and winds not too well defined, you can't be sure there will not be a thunderstorm within 100 miles. You can select days, if you wish, on which this can be forecast very accurately.

Mr. VANDER JAGT. You said with a high degree of certainty. How many days of the year—just a ballpark figure—would we have a 95-percent degree of certainty that these conditions would continue to exist for 8 hours?

Mr. WILLIAMS. It varies an awful lot from season to season. I would say in the fall you have quite a few days. In the winter, less. In the spring, very few. In the summer, quite a variable amount. Of course the summertime is when you get most of your thunderstorms. Out of a 90-day summer season there may be only 25 days at the most that you could really make this statement, that within a hundred miles there will be no thunderstorms, with a high confidence of 95 percent.

Mr. VANDER JAGT. So we are not talking about too many days in the entire year?

Mr. WILLIAMS. No. In the summertime the majority of days you probably could not say this.

Mr. VANDER JAGT. Dr. Osguthorpe, I congratulate you on a very forthright statement. I would like you to clear up any misimpressions that I might have, if you would.

Is my understanding correct that when you first conferred with the Army, and were trying to determine the cause of death of the sheep, that the Army knew the cause?

Dr. OSGUTHORPE. I didn't say they knew the cause. I said that they—when I first conversed with the Army on the cause of the death of the sheep, thinking that it was an organophosphate poisoning, they denied they had used any organophosphate compounds on the proving ground since last July. This was in March.

Mr. VANDER JAGT. That seriously complicated your ability to make an accurate diagnosis, didn't it?

Dr. OSGUTHORPE. You had to be real sure of your diagnosis, at least, in the face of these denials because we had contacted the ranchers in the area and they hadn't used any organophosphate compounds to do any spraying on the alfalfa; so this was our only source of an organophosphate compound in this area.

Mr. VANDER JAGT. Had you not been, shall we say, misled and had your original diagnosis been confirmed, would you have had a chance of saving some of the sheep?

Dr. OSGUTHORPE. This came out in the investigation and it was agreed that a large number of the sheep could have been saved had we known earlier that it was an organophosphate compound and had we been advised of the antidote that is necessary to counteract this particular agent. And we had no information of this until the investigation was underway for a considerable time. Then it was brought out that massive doses of atropine sulfate, along with 2-PAM, would have been quite effective in counteracting the toxicity of this compound if given earlier.

Mr. VANDER JAGT. So there is a good chance some of the sheep could have been saved had you initially been more fully informed by the Army.

Dr. OSGUTHORPE. Yes.

Mr. VANDER JAGT. Then you also testified on page 4 that you were assured, I take it by the Army, that there would be no danger from the agent 4 days after the tests were conducted; is that correct?

Dr. OSGUTHORPE. That is correct. The scientific director at Dugway advised me that using this product—through hydrolysis decomposition and degradation—in 4 days there would be absolutely no danger.

Mr. VANDER JAGT. Did that prove to be true?

Dr. OSGUTHORPE. This proved to be false.

Mr. VANDER JAGT. There was in fact danger for up to at least a month's period?

Dr. OSGUTHORPE. Yes.

Mr. VANDER JAGT. I also want to be crystal clear that I understand your testimony, that you found evidence that there were diseases that had come into the area even before this test.

Dr. OSGUTHORPE. You mean chemicals.

Mr. VANDER JAGT. Yes.

Dr. OSGUTHORPE. Yes. During the investigation, when there was an identification of the particular agent, it was discovered that the bis-simulant that they used in their simulated testing had been escaping from the Dugway Proving Ground and was present in the area where the sheep were. Also, some of the other chemicals that they had used in other types of testing were present in the area where the sheep were.

Mr. VANDER JAGT. I don't believe we have your comment, knowing that there is persistency for up to a month, on the recommendation that weather conditions should be such as to not permit a cloud to go across Highway 40 within 3 hours after the test. You didn't comment on that issue, did you?

Dr. OSGUTHORPE. My comment on this 3-hour time limit, Mr. Vander Jagt, is the fact that they hope there will be plenty of air dilution and air mixing to dilute the material to a point where it is safe by the time it reaches Highway 40.

Mr. VANDER JAGT. Perhaps we are hurrying you into an area where you don't have the expertise but you said it is their hope that it will be diluted within 3 hours.

Do you have an opinion as to whether or not it would be?

Dr. OSGUTHORPE. I have an opinion on this because this cloud that caused the trouble would have had to have gone north of Highway 40 and come back across Highway 40 and be deposited over the sheep; so the fact remains that you will not get enough dilution by the time it reaches Highway 40 to reduce it to a nontoxic condition.

The other thing, when they were talking about the altitude here: This test was made at 150 feet and the ad hoc committee came back and said we will allow you to go up to 300 feet; but this particular test was conducted at 150 feet. So we were just 50 percent of the altitude that you are going to allow them to test at. I think these two points in the ad hoc committee's report are wrong as far as the safety testing at the proving grounds is concerned.

Mr. VANDER JAGT. Apparently the Army has some concern about the adequacy of 3 hours in that I believe you testified to the chairman that the sheriff has closed off Highway 40 on occasion.

Dr. OSGUTHORPE. Yes. This happened real early in the investigation when Sheriff Gillette was real sympathetic toward these ranchers that were losing their livestock and he volunteered to send information—before the Army had admitted they had been conducting these tests—and this information was volunteered by the sheriff prior to March 22, 1968.

Mr. VANDER JAGT. You wouldn't have any rough estimate of how many times he has had to close off Highway 40, would you?

Dr. OSGUTHORPE. No. He just volunteered this while we were starting the investigation.

Mr. VANDER JAGT. Dr. Osguthorpe, I would like to read you something that appeared in a national magazine and ask you to comment on it and clear up, if it needs clearing up, any misimpression that I have drawn.

First it describes you in very glowing terms and then, referring to you, says: "Although the veterinarian was given a quick security clearance he soon became the one man the Army could not control. During the investigation Dr. Osguthorpe said the Army continued to deny responsibility under the wrap of secrecy. The military allowed Osguthorpe to see the color films of the test and made it clear they were at fault but they demanded that the veterinarian go along with them publicly."

Would you comment on that?

Dr. OSGUTHORPE. I don't think that I have gone along with the Army publicly. I deny this.

Mr. VANDER JAGT. I don't think you have either. I really commend you for your forthrightness.

What I am really interested in with regard to that statement is this: Did the military make a demand that you go along or request that you go along publicly, contrary to what you knew to be the truth?

Dr. OSGUTHORPE. Real early in the investigation the Army requested that I be a little less critical of them, and this started the first day that I met with the Army; and other than that I don't think that they altered my actions at all.

Mr. VANDER JAGT. Did they try?

Dr. OSGUTHORPE. Just this one particular day that they tried.

Mr. VANDER JAGT. What is the gist of what they said to you at that time?

Dr. OSGUTHORPE. They would appreciate it—let's see how could I say it—they would appreciate it if I would not make any rash statements to the press.

Mr. VANDER JAGT. That was before they had admitted that they were testing this material just prior to the sheep deaths.

Dr. OSGUTHORPE. This was prior to the time that they had admitted that they were testing the material.

Mr. VANDER JAGT. And at that point, the press was trying to determine what caused the death of the sheep.

Dr. OSGUTHORPE. Yes.

Mr. VANDER JAGT. What do you think they meant, then, by not making any rash statements to the press?

Dr. OSGUTHORPE. Well——

Mr. VANDER JAGT. Let me ask one question first. They knew you knew at that time what caused the death of the sheep; didn't they?

Dr. OSGUTHORPE. Yes, I believe they did.

Mr. VANDER JAGT. One final question, Doctor, and I thank you for your candidness.

Have you, even before this, for a period of 3 to 5 years, run into diseases in sheep in this region that you, a foremost authority on sheep diseases, had been unable to account for?

Dr. OSGUTHORPE. No. I don't think we have had any diseases in sheep in this area. We have had some diseases in newborn calves for which we have not been able to find any antibiotic or drug that provides any therapeutic value.

Mr. VANDER JAGT. Does this puzzle you?

Dr. OSGUTHORPE. This has puzzled me, yes. This is immediately adjacent to the Dugway Proving Ground.

Mr. VANDER JAGT. Do you have any hypothesis as to what could have caused it?

Dr. OSGUTHORPE. I do have, but I better not divulge them now.

Mr. VANDER JAGT. All right.

You have been a very cooperative witness.

Dr. Van Kampen, your research took you into the areas of the effects on cattle and horses, did it?

Dr. VAN KAMPEN. In the analysis of the blood cholinesterase only.

Mr. VANDER JAGT. You have heard the testimony immediately preceding, haven't you?

Dr. VAN KAMPEN. Yes.

Mr. VANDER JAGT. Do you have any theories as to what might have caused the problem with the newborn calves?

Dr. VAN KAMPEN. I don't know which particular group of calves Dr. Osguthorpe is referring to, although there were several calves from that area autopsied at the State diagnostic laboratory in Logan this past spring and, as far as I know, no diagnosis was rendered as to the difficulty in the calves.

I might say that diseases of the newborn calf, the neonate, are sometimes very difficult to diagnose.

Mr. VANDER JAGT. Have you discovered any other effects on, say, the milk of cattle in your studies?

Dr. VAN KAMPEN. No, sir.

Mr. VANDER JAGT. You have not?

Dr. VAN KAMPEN. No, sir.

Mr. VANDER JAGT. Have you, Dr. Osguthorpe?

Dr. OSGUTHORPE. No. There are no dairy cows in this area. It is all sheep and beef cattle, horses. That is about the extent. There is some wildlife in the area.

Mr. VANDER JAGT. Have either of you run into any indication at all of possible deaths of 1,700 cattle?

Dr. OSGUTHORPE. No.

Dr. VAN KAMPEN. No, sir.

Mr. VANDER JAGT. Would you have been likely to run into some indication of cattle deaths if there were 1,700 dead?

Dr. VAN KAMPEN. Very definitely.

Dr. OSGUTHORPE. Yes, sir.

Dr. SIDEL. May I comment on the question about the sheriff of Tooele County and the number of times Highway 40 has been closed?

This Science magazine, the Journal of the American Association for the Advancement of Science, in December 27, 1968, article by Philip Boffey, says:

> Fay Gillette, sheriff of Tooele County, Utah, for the past 22 years, told Science that on several occasions some 6 or 7 years ago he received "confidential calls" from Dugway, generally in the evening, asking him to patrol U.S. Highway 40, 35 miles north of Dugway, and tell people who are stopping along the side of the road to get moving. "They never told me why and I never asked them," says Gillett.

Mr. VANDER JAGT. Thank you.

Since you volunteered, let me ask you if you would care to hypothesize—if a rare disease was discovered in newborn calves, unknown to the veterinarian with vast experience in that area, would you, or could you, project any conjecture as to what might have caused that rare disease?

Dr. SIDEL. I don't often know when I am out of my depth, but on newborn calves I am out of my depth.

Mr. VANDER JAGT. We can't transfer you from Harvard Medical School to calves in Utah.

All right. Dr. Davis?

Dr. DAVIS. I don't know what is being tested in the way of biologicals at Dugway Proving Ground. We have many hypotheses. We kicked around the question of whether VEE had spread from the proving grounds or whether this is an epidemiologic study. Certainly the possibilities exist but I have no idea what is being tested.

Mr. VANDER JAGT. Thank you, Mr. Chairman.

Mr. REUSS. Mr. Gude?

Mr. GUDE. In regard to this disease of newborn calves, do you have any idea whether this is—is there any thought as to whether it is a biological agent or a chemical agent that is causing the difficulty? I hope that I am using these terms correctly. "Biological" meaning some disease producing bacteria or virus and chemical like the nerve gas.

Dr. OSGUTHORPE. Itis my theory that this is a toxin.

Mr. GUDE. It would be a biological——

Dr. OSGUTHORPE. Biological in nature.

Mr. GUDE. Thank you.

Dr. VAN KAMPEN. I might volunteer this information: At the time that they started to lose newborn calves, the attending veterinarian

for the Anschutz Land & Livestock Co. called on the telephone and asked if the forage could be tested. He was sure we had nerve gas again.

As a precautionary measure, cholinesterase analysis was determined on the blood of a number of young calves and no depression was shown at all.

Mr. VANDER JAGT. Is it possible there were 1,700 dead young calves?

Dr. VAN KAMPEN. I am afraid not.

Mr. GUDE. Dr. Sidel, in your statement on the middle of the second page, you spoke about the difficulties in the detoxification or destruction of such substances.

Is a nerve gas such as parathion and VX, are they easily broken down with lime or quick lime, or is it a difficult material to deal with?

Are you speaking in the natural state that detoxification is difficult?

Dr. SIDEL. I know of no specific evidence one way or the other on detoxification of these substances. I base my conclusion on the fact that rather than adopting some other detoxification method, the Army is choosing this particular one to dispose of this material.

I assume that if there were a simpler method they would be using it but I have no specific information on it.

Mr. GUDE. Well, parathion is a related chemical.

Is that easily disposed of and broken down or would you have to—would you resort to putting——

Dr. SIDEL. I don't know the answer to the question. I could try to find that out for you but I don't know about the breakdown of parathion.

Dr. DAVIS. The nerve gases can be relatively easily hydrolyzed. In other words, the bond between the phosphate and the rest of the gas compound can be broken down by a relatively weak alkaline solution and/or heating. Apparently this is chemically simple and is described in organic chemistry textbooks available for many years. Industrially, with the mass of gas available, this may be difficult but, as was put in testimony in Congressman Gallagher's committee earlier in the week, this is no problem. Parathion is similar, though I don't know specifically how it may be detoxified.

Mr. GUDE. In other words, it is fairly easy to break these down artificially, though in the natural environment they could have a much longer residual effect.

Dr. DAVIS. Apparently.

Dr. VAN KAMPEN. One problem with parathion in the environment is that its breakdown products are more toxic than the parent compound. So this is one of the problems you run into with that particular agent.

Mr. GUDE. I am afraid I was a little late and you were asking about the lethal dose of the nerve gas.

Did anyone make a—I believe it is unknown what the lethal dose is.

Is there any knowldge of what the lethal dose is a far as sheep are concerned? It is not known as far as humans are concerned, is that right? Unknown for either?

Dr. DAVIS. Sheep are known.

Dr. SIDEL. One can make the guess that the lethal doses are in the

milligram range for humans. But a precise figure is classified so far as we know.

Dr. DAVIS. I hope there are no experimental data concerning lethality for humans.

Dr. VAN KAMPEN. It depends on the route of administration. Intravenous, inhaled, oral, percutaneous.

Mr. GUDE. Thank you.

Mr. REUSS. Mr. Hicks?

Mr. HICKS. Mr. Chairman, I am sorry I didn't get to participate in all this but I did want to ask one thing: Is my understanding correct that the only interference or concealment that the military made in all this is that one statement, please don't make any rash statements?

Mr. REUSS. You will have to ask the witnesses. There has been testimony from the witnesses that the military officials at Dugway denied repeatedly that there had been any VX nerve gas testing.

Mr. HICKS. Up until they were found out. After that they said don't make any rash statements.

Mr. REUSS. I should retire from the witness stand. [Laughter.]

Mr. HICKS. Is that correct?

Dr. OSGUTHORPE. That is right. I made a press release and they took me to task on it right away, quick.

Mr. HICKS. You can understand the military deals with Congressmen quite frequently and they are somewhat gun shy of rash statements. They may not have the same problem with the medical profession or the scientific profession. But I am sorry, Mr. Chairman, this sounded very interesting. I wish I had been able to hear all of it but I had other duties that seemed to be more compelling.

Mr. REUSS. We are delighted you are here. There will be other witnesses.

I hope you can stay, Mr. Hicks.

Dr. Van Kampen, you say in your testimony that what may have saved some of the horses and cows in the general vicinity of Skull Valley from dying in the night on March 13 was that they have cholinesterase enzymes present in their serum which may have had a buffering effect and thus given them more resistance to the killer gas than the sheep had; is that your testimony?

Dr. VAN KAMPEN. That is correct.

Mr. REUSS. Actually how closely intermingled were the cows and horses with the sheep in Skull Valley and the adjoining regions?

Dr. VAN KAMPEN. There were two large bands of sheep grazing up high behind the White Rock area at the time of this occurrence. The cattle were grazing on the plain below the White Rocks and between the White Rock area and what is known as the Indian reservation area. This is where the main group of cattle were grazing. There were also cattle in a feed lot up against the Stansbury Mountains at the small town of Terra and these cattle showed lower cholinesterase levels while cattle in the northern end of Skull Valley and the south of Skull Valley didn't show lower cholinesterase levels.

Mr. REUSS. So if I get your testimony correctly, the horses and cattle weren't particularly intermingled with the sheep and, therefore, the survival of the horses and cattle contrasted with the death of the sheep may have been due at least in part to the fact that none of this deadly nerve gas landed on or near them.

Dr. VAN KAMPEN. This may well be so, with the exception of the fact that the cattle and the horses did have a lower cholinesterase level.

Mr. REUSS. So they got some but not enough to kill them.

Dr. VAN KAMPEN. That is correct.

Mr. REUSS. Question: Do human beings have cholinesterase enzymes present in our serum which may make us somewhat resistant to VX?

Dr. VAN KAMPEN. Yes, we do.

Mr. REUSS. But not enough so that we wouldn't be quite dead if we really got near it.

Dr. VAN KAMPEN. It is entirely a matter of dosage and route of administration, again. The sheep were eating the material over a period of time. Not all sheep came down with the poisoning at the same time. Although a large number of them did.

Mr. REUSS. Dr. Osguthorpe, perhaps you can give us in more detail the chronology of the statements by the Army.

The nerve gas dispersion was on the night of March 13, 1968.

Dr. OSGUTHORPE. Early in the evening of March 13.

Mr. REUSS. When did you first hear tell of the disaster of the sheep?

Dr. OSGUTHORPE. I first heard tell of the disaster on March 19.

Mr. REUSS. Governor Rampton of Utah, I believe, appointed you as the State of Utah representative to try to get to the bottom of the troubles.

Dr. OSGUTHORPE. Yes.

Mr. REUSS. And did you do anything about this prior to March 19?

Dr. OSGUTHORPE. No.

Mr. REUSS. When did you move into action?

Dr. OSGUTHORPE. On March 19. Commissioner Waldron and myself flew to the site where the sheep were dying in my airplane in the late afternoon of March 19, and these were the first sheep I posted.

There were, as I stated before, no visible lesions that would indicate the cause of the death of these sheep.

Mr. REUSS. When did you first make contact with Army officials in connection with this sheep-kill? On that date, the 19th or later?

Dr. OSGUTHORPE. No, on March 20.

Mr. REUSS. The next day.

Dr. OSGUTHORPE. Yes.

Mr. REUSS. Whom did you see and what did he tell you?

Dr. OSGUTHORPE. I saw Dr. Rothenberg and Colonel Watts.

Mr. REUSS. Dr. Rothenberg's office was what?

Dr. OSGUTHORPE. He is a scientific director of the Dugway Proving Ground.

Mr. REUSS. And Colonel Watts?

Dr. OSGUTHORPE. Commanding officer of the Dugway Proving Ground.

Mr. REUSS. Which of those gentlemen told you what with respect to nerve gas testing?

Dr. OSGUTHORPE. Commissioner Waldron and myself were both there in their office and they said that they hadn't been doing any testing since last July.

Mr. REUSS. Of VX?

Dr. OSGUTHORPE. Of VX—of organic phosphate compounds.

Mr. REUSS. Did both Colonel Watts and Dr. Rothenberg make that statement?

Dr. OSGUTHORPE. They both concurred in this statement. We did most of the talking. Well, we were just sitting around the table in Colonel Watts' office and discussing this back and forth.

Mr. REUSS. Was that the only statement made to you on March 20 by any representative of the Army concerning nerve gas testing?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. When was the next statement made by representatives of the Army after March 20 concerning nerve gas testing?

Dr. OSGUTHORPE. Well, I returned to the area on March 20 and I went back to the area on March 21 with the Governor and March 22 was the first actual contact that I had with the Army again.

Mr. REUSS. Whom did you see from the Army on March 22, and what did they say?

Dr. OSGUTHORPE. That was at a special meeting that the Governor called at the State capital and the Army was invited to it and Colonel Watts and General Stone——

Mr. REUSS. Who is General Stone?

Dr. OSGUTHORPE. General Stone was sent out from Washington to investigate this matter. He and General Appel, who is now commanding officer of Deseret Chemical, and Dr. Rothenberg and Colonel Watts were the four individuals that were at this meeting, as I recall.

Mr. REUSS. In the Governor's office in the State capital.

Dr. OSGUTHORPE. In the Governor's office, yes.

Mr. REUSS. And did any of those four gentlemen have anything to say about whether nerve gas tests had been conducted at Dugway on that occasion?

Dr. OSGUTHORPE. It was stated at that meeting that they had conducted nerve gas testing on the 13th. Prior to this——

Mr. REUSS. Who stated that they had done that?

Dr. OSGUTHORPE. I think General Appel was the spokesmen for the group at this meeting.

Mr. REUSS. Did you, at that time, indicate any disappointment based on the fact that if they told you the truth 2 days before you could have used preventive medical measures and saved a considerable number of the sheep?

Dr. OSGUTHORPE. I am sure that had they divulged the fact that they had been using organic phosphate compounds, upon first learning of the death of these sheep a lot of the disaster could have been averted.

Dr. SIDEL. May I insert an event that happened in Washington between these events taking place in Utah?

Again, Mr. Boffey, writing in "Science":

> The Army's initial reaction to news of the sheep deaths was to deny that Dugway had been doing any testing that could have caused the incident, but this posture had to be abandoned when the office of Senator Frank E. Moss revealed on 21 March that Dugway had conducted three separate nerve agent operations on 13 March.

March 21 was the day between the first meeting at Dugway and the day in the Governor's office Dr. Osguthorpe referred to.

> The Army had supplied the information to Moss and apparently intended it to be "for official use only," but Dale O. Zabriskie, press assistant to Moss, says there was no restrictive marking on the document so he promptly released the information to Utah newsmen, much to the Army's consternation.

Mr. REUSS. Thank you.

Dr. OSGUTHORPE. Coming back to this, after Senator Moss had released this information, the word came back that this was false and that he had been given erroneous information and the Army still denied they had been testing.

Mr. VANDER JAGT. Where did that come from?

Dr. OSGUTHORPE. This came back from Washington—that this was erroneous information that had been given Senator Moss and they still denied it.

Mr. REUSS. How did this information from Washington, from the Army, reach you?

Dr. OSGUTHORPE. At the Governor's office at the meeting that was held the 22d.

Mr. REUSS. Well, I am a little confused.

Dr. OSGUTHORPE. You mean this erroneous information period?

Mr. REUSS. Let's review the bidding. [Laughter.]

On March 21, you met with the Army—no, on March 20 you met with the Army. They gave you incorrect information saying that there had been no VX testing since the preceding July. On March 21 you were on the sheep-kill site but you didn't meet with any Army people. On March 22, at a meeting in Governor Rampton's office, you were informed by General Appel of the——

Dr. OSGUTHORPE. He is a commanding officer of Deseret Chemical now. He took Colonel Watts' place when they merged Deseret Chemical and Dugway Proving——

Mr. REUSS. But he was from Washington then. He told you there had been a test of VX on March 13.

Dr. OSGUTHORPE. This was revealed at the meeting at the Governor's office.

Mr. REUSS. Then Dr. Sidel just testified that on March 21, the day before the meeting in the Governor's office, Senator Moss had inadvertently released confidential information given to him to the effect the Army lied on March 20 but was telling Senator Moss the truth on March 21. Then on March 22 General Appel affirmed the information that had come from Senator Moss' office.

Now after March 22 I gather the Army then did its fourth flip-flop on this and again took the position that there had been no testing of nerve gas.

Dr. OSGUTHORPE. No. They reversed themselves prior to this meeting. Senator Moss released this information and then the information came back out to the State capital at Utah that this was wrong and they hadn't been doing any testing. This came right shortly the same day.

Mr. REUSS. On March 22?

Dr. OSGUTHORPE. 21.

Mr. REUSS. I see.

Dr. OSGUTHORPE. Senator Moss announced that they had been testing and this was retracted the same day.

Mr. REUSS. By whom?

Dr. OSGUTHORPE. By Washington, I presume. By the Army. They said this was——

Mr. REUSS. How did you hear of the Army's——

Dr. OSGUTHORPE. I heard through the Governor at the capital that this had been retracted.

Mr. REUSS. So then the chronology to date is: On March 20, Army denial they had tested nerve gas.

On March 21, Army admission through Senator Moss' office that they had tested nerve gas.

Dr. OSGUTHORPE. Then denied.

Mr. REUSS. March 21, later in the day, Army denial that they had tested nerve gas.

On March 22, through General Appel, Army admission they had tested nerve gas.

After that, did the Army again ever take the position that it had not tested nerve gas at Dugway?

Dr. OSGUTHORPE. No.

Mr. REUSS. Does the Army today concede that in the light of its very extensive testing of nerve gas on March 13, and in the light of the almost immediate death of several thousand sheep downwind from that test, and in the light of the later findings by the Atlanta laboratory that those sheep contained dosages of VX—has the Army to this date admitted that its testing might have had something to do with the death of those sheep?

Dr. OSGUTHORPE. No. In fact I would like to quote a piece from the "Deseret News," December 7, 1968. This is written by Steven Hale, the "Deseret News" medical writer, and he is investigating the sheep deaths and interviewing Brig. Gen. John G. Appel and he states:

> General Appel said if an airplane should rupture a tank of nerve agent a fire would ignite the oily substance and destroy it. Smoke from burning nerve agent is not dangerous, he said. Vapor escaping from nonburning agent can be perilous though, he said. The General pooh-poohed any possibility of heavy steel tanks rupturing from the effects of an earthquake. As for the sheep deaths, General Appel said he didn't think the nerve gas sprayed by a high performance plane just before the animals started dying was the case.

Mr. REUSS. Thank you.

Gentlemen, I have asked you all to consider with this subcommittee the various recommendations made by the Army and its ad hoc advisory committee on November 1968 to prevent repetitions of the Dugway matter. I want to ask each one of you this question: In your judgment, do the present testing procedures carried out by the Army pursuant to the ground rules laid down in the November 1968 recommendations adequately protect human and animal life?

Dr. DAVIS. I don't know if the recommendations have been carried out.

Mr. REUSS. Let me rephrase the question.

Do these recommendations, if they are carried out, adequately protect human and animal life?

Dr. DAVIS. Not completely.

Dr. SIDEL. No.

Mr. REUSS. Dr. Osguthorpe?

Dr. OSGUTHORPE. I would say that this recommendation by the ad hoc committee does not alter the testing procedure at Dugway one iota.

Mr. REUSS. Which, in your judgment, was not a testing procedure that took adequate care of the lives and safety of the American citizens and of the ecology.

Dr. OSGUTHORPE. We have proof this is not adequate or we wouldn't have run into this situation.

Mr. REUSS. Mr. Williams?

Mr. WILLIAMS. The meteorology point seems to be generally okay to me. I wouldn't have any comment on anything else, on the toxicity.

Mr. REUSS. Dr. Van Kampen?

Dr. VAN KAMPEN. I would have to give a qualified no.

Mr. REUSS. Thank you very much.

Any questions?

Mr. Indritz?

Mr. INDRITZ. Mr. Williams, directing your attention to page 26 of the Interagency Ad Hoc Advisory Committee report, paragraph 5–A reads as follows: "It is well known that some particles on the ground are resuspended by the action of the strong wind which can occur at Dugway Proving Ground. Some soil or other particles in the test area may be heavily contaminated by chemical agents. * * *"

This is the statement by the investigating committee.

In the light of your examination of the weather conditions in the area, do you concur with that statement of the ad hoc committee as indicating a probability that in the case of strong winds the particles that may be on the ground might be resuspended in the air and carried for many miles?

Mr. WILLIAMS. This is true. This does happen. Particles will be lifted up and resuspended and particles from the Great Salt Lake Desert, for instance, can be brought in over Salt Lake City. If there is a light rainfall they can be deposited out. You see this on automobiles or houses, a grayish white coating. This will happen in spring storms, occasionally.

Mr. REUSS. Pursuing that, while this goes outside your field of expertise there has been testimony from your colleagues on the panel that sheep died 3 weeks or a month after the nerve gas tests from residues which had evidently continued in or about the terrain.

Assuming that is right, and that the sheep were in fact killed by a nerve gas dispersion that had occurred several weeks before, is there not a danger that dust, soil, dirt, whatever the terrain is composed of, containing nerve gas residues, could be wafted up into the air and deposited many miles from the place where that dust or soil originated?

Mr. WILLIAMS. Certainly the dust or soil could and would be at times resuspended and wafted up and carried many miles away. As to whether it would contain any harmful particles, I wouldn't want to say.

Mr. REUSS. I didn't ask you that point because that is not within your field of competence. How far could these particles of earth be carried, having in mind the general movement of winds in and around the Dugway area?

Mr. WILLIAMS. They could certainly easily be carried up to 100 miles. We have known that in dust storms with very strong winds dust particles have been carried several hundred miles down wind. Up to a hundred miles or in extreme conditions they could be carried more than a hundred miles.

Mr. REUSS. If these particles then are capable of carrying residues of VX, a question which I do not ask you to discuss, they then could have a

catastrophic effect upon the great population centers 100 miles to the east, could they not?

Mr. WILLIAMS. I am not sure that particles are capable of carrying VX.

Mr. REUSS. I deliberately excluded that because that is for other witnesses. If they are capable of carrying VX, those particles are under foreseeable wind conditions in that area, capable of being carried over Salt Lake City and other population centers of Utah, are they not?

Mr. WILLIAMS. The particles themselves would be capable of being carried by the winds several hundred miles and could reach populated areas of Utah.

Mr. REUSS. How far away is Salt Lake from Dugway?

Mr. WILLIAMS. Eighty miles.

Mr. REUSS. Any further questions?

Gentlemen we are grateful not only for your patience but for your expert contribution and, if I may say so, for your honesty.

Thank you very much.

Dr. SIDEL. Might I interrupt once more to add to the chronology. I hope it is clear to the subcommittee that this chronology begins on the 20th of March, whereas the accident occurred on the 13th and the sheep began to be sick on the 14th. It seems clear that the Army did not feel it was worth admitting this error to save the lives of some 6,000 sheep during this period. It might be worth while asking them, if one might respectfully recommend a question to the subcommittee, how many lives of human beings would have to be sacrificed before an admission of a mistake would be made?

Mr. REUSS. I have one more question to ask Dr. Osguthorpe.

In going through the chronology with you a moment ago, the first contact you personally had with the Army on whether or not they had been testing nerve gas was on March 20, which was about 6 days after——

Dr. OSGUTHORPE. One week exactly.

Mr. REUSS. One week after the critical date.

My question: Had you become aware by means other than your contact with the Army—and I am aware of the fact you weren't in direct contact with the Army—but had you become aware by other means that the Army was denying that it conducted any nerve gas tests?

Dr. OSGUTHORPE. Yes, I had.

Mr. REUSS. How, Dr. Osguthorpe? Through reading the papers?

Dr. OSGUTHORPE. Through employees at Dugway Proving Ground.

Mr. REUSS. And what did they say?

Dr. OSGUTHORPE. They said there had been testing.

Mr. REUSS. They said there had been testing.

Dr. OSGUTHORPE. Yes.

Mr. REUSS. But——

Dr. OSGUTHORPE. I learned this on the 19th.

Mr. REUSS. Now when did you first hear of the sheep-kill? I take it almost immediately.

Dr. OSGUTHORPE. The 19th.

Mr. REUSS. Not until the 19th?

Dr. OSGUTHORPE. I was in California when this happened.

Mr. REUSS. Dr. Van Kampen?

Dr. VAN KAMPEN. Could I fill in some chronology?

Mr. REUSS. Please do. I would like to take this back of March 19, which is the first time that Dr. Osguthorpe really appeared on the scene.

Were you there on the 13th?

Dr. VAN KAMPEN. Not on the 13th. The sheep began to die on the 14th. On the evening of the 14th, a veterinary practitioner, Dr. Marr Fawcett, was called in to attend to the sheep on the 15th. He was in touch with our office the evening of the 15th, and again on the 16th.

That was on Saturday. On Sunday morning, Dr. James and myself arrived on the scene in Skull Valley, and it was on that day that we autopsied 16 sheep and came to a diagnosis of a chemical poisoning affecting the nervous system.

Mr. REUSS. You say that was Sunday?

Dr. VAN KAMPEN. Yes, Mr. Reuss. On that particular day the manager of the Anschutz Land and Livestock Co. was instructed to contact the Dugway Proving Ground to see whether or not tests had been conducted, and he made that contact that particular evening.

Unfortunately, he contacted an officer connected with the biological division, and that was the first information that was given that no testing had been conducted that particular week. That was on Sunday, March 17.

Mr. REUSS. On March 17, the Army was informing the owner of the sheep no testing had been conducted?

Dr. VAN KAMPEN. By one officer from the biological section. There was no official proclamation from the Army on that date.

So that's the chronology up to that particular time.

Mr. REUSS. So far as you know, Dr. Van Kampen, the first time the Army admitted, directly or indirectly, that there had been nerve gas tseting at Dugway was on March 21, when Senator Moss' office here in Washington seems to have been informed of it?

Dr. VAN KAMPEN. Yes; that is correct.

Mr. HICKS. Could I ask a question? Are you saying, when you say an officer of the biological department, that there had been no biological testing that week? Is there a difference between biological and chemical testing?

Dr. VAN KAMPEN. Yes, sir; separate divisions.

Mr. HICKS. Which had this been?

Dr. VAN KAMPEN. Chemical testing.

Mr. HICKS. So that could have been an accurate statement that that officer made?

Dr. VAN KAMPEN. Yes.

Mr. HICKS. Without any effect of concealment as they later did?

Dr. VAN KAMPEN. That's correct.

Mr. REUSS. Was the question asked by the manager of Anschutz of the Dugway official on March 17, whether there had been testing of poisonous agents, or whether there had been testing of biologicals?

Dr. VAN KAMPEN. I think the question was, "Had there been unusual testing?"

Mr. REUSS. And the answer was, "No, there hadn't been"?

Dr. VAN KAMPEN. That's correct.

Mr. REUSS. So far as the manager of Anschutz was concerned, the answer he thought he was getting was there hadn't been any testing of anything that might have killed his sheep?

Dr. VAN KAMPEN. That's correct.

Mr. REUSS. Just one more question. There has been testimony by, I believe, Congressman McCarthy that almost immediately after the sheep-kill, the public relations officer for Dugway, Tom Donnelley, denied that there had been any tests.

Are any of you familiar with that? Apparently, an additional statement by an Army official.

All right. Thank you again, gentlemen. We appreciate it very much.

We will now ask our two remaining witnesses for this afternoon, Dr. James Keith, research biologist, U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife, and Dr. Clarence C. Gordon, plant pathologist and professor of botany, University of Montana, to come forward.

Thank you, gentlemen, for your patience.

We have your statements which will be admitted in the record, without objection.

Would you proceed?

STATEMENT OF JAMES O. KEITH, RESEARCH BIOLOGIST, U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF SPORT FISHERIES AND WILDLIFE, DAVIS, CALIF.

Mr. KEITH. I am James O. Keith, a research biologist in the Bureau of Sport Fisheries and Wildlife. For the past 8 years, I have been stationed at Davis, Calif., and engaged in research on the effects of pesticides on wildlife in Western States. The Bureau has conducted such studies for over 20 years.

The appropriation of funds specifically for pesticide-wildlife investigations greatly accelerated our acquisition of knowledge during the last decade. Still, we are confronted with hundreds of possible effects on thousands of species of wildlife from any of the vast array of pesticides now in common use. Today, even with our considerable knowledge, much more remains unknown than known about pesticide-wildlife relationships.

INTRODUCTION

All applications of toxic chemicals have effects on wildlife. To my knowledge, each intensive field study has documented some influence of pesticides on vertebrate animals. Such findings were not unexpected for ecologists realize that the environment is a system of interrelated forces and organisms. If one factor is altered, there are ramifications throughout the affected ecosystem. The problem usually has been to identify the effect, to assess the severity of its impact on wildlife populations, and to bring about changes in pest control programs so that wildlife damage is minimal.

Pesticides are widely used and it is clear even to the casual observer that most applications do not cause the immediate death of large numbers of animals.

However, mortality is just one of many possible effects of pesticides on wildlife, and effects other than death usually are much more difficult to identify and evaluate.

For example, during the past 5 years, a great volume of information has been accumulated on the contamination of the environment and

wildlife with DDT. Yet, it was only recently that specific, subtle effects of this contamination were demonstrated. We now know that DDT has reduced reproductive success and caused serious population declines in predatory birds.

This was a result of the DDT effect on calcium metabolism, which caused birds to lay thin-shelled eggs that collapsed during incubation. This phenomenon has been identified in about six species, and for some the effect was catastrophic.

We do not know, and must immediately determine, how widespread this effect of DDT is among birds. It is of interest that quite low levels of exposure to DDT are capable of producing thin-shelled eggs in the species studied.

There is no reason to expect that only DDT can produce subtle effects such as these. We simply have not had the time and money to thoroughly investigate the impact of other pesticides such as the organophosphate insecticides on wildlife reproduction and longevity. It would be foolish to assume that because effects have not been documented they do not exist.

Studies have shown that the intensity and scope of pesticide activity and effects vary depending on where and when they are used. Such variation requires that evaluations of each pesticide be made in the environment where it occurs as a contamination. It is unwise to extrapolate between chemicals and environments to predict effects of pesticides.

I have not had experience in studying organophosphorus, cholinesterase-inhibiting chemicals in the Great Basin of the Western United States.

I can relate findings on the behavior and effect of organophosphates and other insecticides in California. Involvement of organophosphates in ecological relationships of other geographic areas can be expected. The nature, intensity, and effect of those involvements will require specific study.

BEHAVIOR AND EFFECTS OF ORGANOPHOSPHORUS INSECTICIDES

Critical study of pesticide effects must include basic laboratory investigation, trials under simulated field conditions, and research in natural environments.

Specific effects may be first identified either in the lab, in pens, or in the field. But an understanding of pesticide persistence and accumulation, and pesticide influence on ecological and physiological processes requires the coordinated effort of specialists in several disciplines.

TOXICITY

All organophosphates are highly toxic to some forms of animal life. The toxicity of an insecticide to diverse animals cannot be predicted from tests against standard organisms.

Trials must be conducted against those animal forms subjected to greatest exposure by uses of the insecticide. For example, parathion is highly toxic to warmblooded vertebrates, whereas malathion is not.

Fish, however, are more susceptible to malathion than to parathion.

Some insecticides of low toxicity to vertebrate animals are highly toxic to either crabs, shrimp, or phytoplankton.

Some species of wild animal are dependent on each lower form of life in the environment, either directly or indirectly. Mortality of even invertebrate life can have an important detrimental influence on birds, mammals, and fish.

DEPOSITION AND PERSISTENCE

Use of organophosphates and other pesticides results in broad contamination of the environment. Treated areas are highly contaminated after pesticide applications. Also, it seldom is possible to restrict pesticides to the areas where treatments are proposed.

In our studies, aerial applications of organophosphates have resulted in only 10 to 50 percent of the insecticide being deposited on treated areas, even when aircraft were flown at a height of only 10 feet. The remaining insecticide may drift onto adjoining lands or rise in air currents to contaminate the atmosphere and at sometime be deposited elsewhere. Residues on soil or in water may reenter the atmosphere through the process of codistillation.

The extent and pattern of airborne insecticide dispersion resulting from the millions of pesticide applications made each year are poorly understood. Airborne transport of pesticides from Texas to Ohio and from European-African land areas to the island of Barbados in the West Indies has been demonstrated. Contaminations on the crest of the Sierra Nevada, in remote areas, and in the oceans suggest considerable movement of pesticides in our atmosphere.

Pesticides are degraded by light, heat, chemical, and biological action. Organophosphates vary in their susceptibility to degradation by each of these factors. Since these factors vary with time and between environments, it is impossible to predict the rate of pesticide degradation. It must be determined by investigation.

Waterfowl and other birds are frequently killed by organophosphates that have persisted for unexpected periods after application.

In 1960, the available evidence indicated that DDT disappeared rather quickly from most treated areas. It was assumed that DDT degraded on treated areas and disappeared from the environment. Our awareness of the extent of DDT contamination in the environment resulted from comprehensive studies using reliable analytical techniques for residue analysis.

Similar research effort on organophosphates probably will show that they also also are more omnipresent than we now assume. Few surveys have been made to depict organophosphate residues in the environment, primarily because of inadequate techniques for analysis of residues in environmental samples.

In 1967, a limited number of water samples from marsh habitats in the Tule Lake National Wildlife Refuge were analyzed for organophosphates. Residues of one or more of five organophosphates were found in all samples each month between April and September. The marsh was not treated with organophosphates and contamination resulted from either airborne deposition or from residues entering the marsh in waste agricultural water.

EXPOSURE OF WILDLIFE

On treated areas, wildlife can be exposed to organophosphates through inhalation, dermal absorption, and ingestion. These either singularly or in combination can cause death.

Long-term, subtle effects on wildlife result mainly from their exposure to residues on their foods. This exposure can occur on or off treated areas and influence both resident and migratory wildlife.

Migratory birds can be subjected to considerable exposure to pesticides and often accumulate high residue levels. Birds that migrate through and winter in areas contaminated with pesticides can accumulate residues that affect their reproductive ability months later in different areas or even in different countries.

This has been indicated in such birds as eagles, falcons, ospreys, pelicans, and ibises.

The degree of an animal's exposure is dictated by its habits and the residues persisting or accumulating in its environment and on its foods. Those species dependent on the most highly contaminated foods are usually subjected to the greatest exposure and hazard. Residues in the environment must be studied to assess which kinds of animals receive greatest exposure.

At Yosemite National Park, we studied the persistence and accumulation of malathion residues in various environmental materials after treatments for forest insect control.

We were told malathion disappeared quickly and we sampled for only 21 days after applications. On most substrates, residues did not persist or accumulate. But levels of 550 p.p.m. (parts per million) were recovered from insects utilized as food by insectivorous songbirds, and levels of 7 p.p.m. remained in the duff of the forest floor after 21 days.

In 1967, some mallard ducks died on all ponds experimentally treated with an organophosphate, irregardless of the rate of application. We observed that after treatments birds fed on affected aquatic invertebrates.

Usually, mallards seldom eat invertebrates. These invertebrates were quickly affected at high rates (1.0 lb/ac) and became distressed somewhat later in ponds treated at lower rates (0.1, 0.05, and 0.01 lb/ac).

Apparently, invertebrates in all ponds accumulated similar amounts of insecticide before becoming affected, and presented a similar exposure to ducks in all ponds.

In 1968, we measured the accumulation of the organophosphate in diverse forms of invertebrates in ponds. Insects and their larvae seldom accumulated more than 1 p.p.m., but residues ranged up to 16 p.p.m. and persisted for 36 days in crustaceans.

Studies show that organophosphates can persist for months in the environment. Insects and other invertebrates can accumulate residues and, as food items, can seriously expose wildlife to organophosphates.

Routine investigations documented these facts; the cases did not represent unique or unusual situations. Further research will probably show that the general intensity of wildlife exposure to organophosphates is similar to that for the chlorinated hydrocarbon insecticides.

EFFECT ON WILDLIFE

Wildlife mortality caused by organophosphates is much more common than generally recognized. In 1968, 30 cases of wildlife losses due to organophosphates were actually investigated in California by the Department of Fish and Game.

Some incidents were not investigated and many others probably were not even reported. In most cases, mortality was the result of exposure on treated areas and occurred shortly after application of organophosphates.

I would like to add that these uses were not misuses. The treatments were made following recommendations and the uses were registered.

Many organophosphates are apparently rapidly degraded from their original form in the bodies of vertebrate animals. Recovery of the parent material is usually difficult unless the animal received massive exposure.

Examination of the gastrointestinal tract is, perhaps, the best means of determining by residue analysis if an animal has been recently exposed to organophosphates.

Little information exists on the degradation products of most organophosphates, and few analytical techniques are available for their identification in biological samples. These factors complicate the assessment of sublethal exposure of wildlife to organophosphates and of subtle effects on physiological functions in animals.

It should be mentioned that DDE, a metabolite of DDT, is responsible to a much greater extent than the parent compound for eggshell thinning and population decline in predaceous birds.

The potential for hazard to wildlife from sublethal exposure to organophosphate is great. The insecticides are known to interfere with enzyme systems in animals and they may influence several important physiological functions.

Even with our greater experience and knowledge of DDT, we are just beginning to identify its specific effects and mode of action. Knowledgeable scientists usually have anticipated the effects of toxicants long before studies were conducted and information made available to show exact relationships.

In most animal populations a rather precise balance is maintained between natality and mortality so that each species exists in numbers that can be supported by the available habitat.

Also, the habitat must contain all of the essential life requirements for the species in amounts capable of maintaining population levels. A slight decrease in natality or in habitat quality is much more important than light, periodic mortality. If longevity or reproductive efficiency of individual animals is decreased, natality is decreased, and population decline may follow.

It is for these reasons that biologists are more concerned with the hazards of long-term subtle effects on animal populations than with periodic mortality following pesticide use.

CONCLUSIONS

Assessment of a chemical's effect on wildlife and their environments requires intensive and long-term study. Evaluation of animal mortal-

ity on treated areas immediately following applications is one aspect to be considered.

However, the dispersal, persistence, and involvement of the chemical in ecological systems on and off of treated areas and the resulting exposure and long-term effects on individuals and populations of animals are of even greater importance.

The need for such studies is becoming increasingly apparent. We have already drastically reduced and even extirpated certain forms of highly desirable wildlife from broad geographical areas by our use of pesticides. The relationships in these cases were so complex that it required years of study to identify the pesticides involved, the mechanisms of wildlife exposure, the mode of action, and the specific effects on individual animals that caused population declines.

Very little effort is expended on periodic surveys to assess the status of wildlife populations, especially the nongame species. It has been the serious decline in population levels that drew attention to subtle, long-term effects of pesticides. To date populations of some species have disappeared from extensive areas before remedial action could be initiated.

Apathy and skepticism resulting from the lack of complete, detailed, experimental evidence on cause-effect relationships have prevented the restrictions and regulation of pesticide use necessary to protect wildlife.

In cases such as these, and in others involving general environmental quality, our society must react to indications of undesirable effects from our activities.

When situations are allowed to develop such as pesticide contamination of our environment, and air and water pollution, serious problems will develop and it will be difficult if not impossible to restore the original quality to our environment.

Loss of environmental diversity and quality will drastically impair esthetical values and will seriously reduce the ability of the environment to sustain human life.

Mr. Reuss. Thank you, Mr. Keith.

Dr. Gordon, we have your excellent paper, which will be received in full into the record. Would you proceed now to summarize?

(Dr. Gordon's prepared statement follows:)

PREPARED STATEMENT OF DR. C. C. GORDON, PLANT PATHOLOGIST; PROFESSOR OF BOTANY, UNIVERSITY OF MONTANA

POISONING OF PLANTS AND ANIMALS IN MONTANA

In the last few years Montana has had several instances of poisoning of plants and animals due to chemicals introduced into the ecosystem by the activities of man. With one exception (chlordane residues) these episodes have involved airborne pollutants as the cause of the damage to plants, animals, and man. In all cases some knowledge was available to predict the consequences that ensued; however, those having this understanding failed to act in preventing the pollution or on warning the public what was likely to happen. I propose to sketch for you today several of the more serious disruptions in Montana's ecosystem—their causes, what methods were used to determine the damage, and the effects on plant and animal populations.

The most widely known air pollution problem in Montana is that of Garrison, a small community in west-central Montana. In 1963 the Rocky Mountain Phosphate Co., Inc., opened its cattle feed supplement plant in Garrison. At that

time a stream of complaints began that continues even today after major revisions have been made in the plant's processes and abatement equipment. The first complaints were about the fumes which eased down on the community from the plant's stack. With time the list of effects expanded from the annoyance and ill health of the residents to include damage to paint, glass, auto finishes, withering of vegetation (both in yards and on the mountain slopes) and the crippling of horses and cattle by fluorosis. The Montana State Board of Health, the management of Rocky Mountain Phosphate Co., Inc., and the residents of Garrison engaged in a three-way tussle without any victor until the Federal Governernment was finally requested by the Governor to make an investigation. In this way, Powell County, Mont., became the site of the first Federal Intrastate Air Pollution Abatement Conference. Studies of soil, air, water, vegetation, and animals were conducted which showed that although some vegetation (namely conifers and various garden plants) were affected by the hydrogen fluoride gas which was being emitted, grasses were apparently not damaged. Yet this lack of evident damage on the natural grasses was directly responsible for the most striking aspect of the problem, the crippling of the cattle and horses with fluorosis. Many animals were badly damaged and owners of valuable horses were advised to remove them from the area. This fluorosis was due to the accumulation of fluoride in the plant tissues which upon being eaten by the animals was assimilated. A study of rodents (rabbits and mice) in the vicinity was made and these animals, too, had very high fluoride content in their bones as compared to the normal level. The rodent populations were small, and the usual predator birds were absent in the area.

A similar case of poisoning by fluorides occurred near Hall, Mont., where a phosphate rock crushing plant was operating until about a year ago. In this case, however, the contaminant released into the air was a fine particulate of the fluoride rock rather than hydrogen fluoride gas. A white layer of this fluoride dust was obvious on the vegetation immediately surrounding the plant, and a white cloud of the dust drifted off thru the valley. However, there was apparently no damage to the conifers except perhaps a decrease in photosynthesis because of the layer of dust upon the foliage. The fluoride was not assimilated, and, consequently, did not cause internal necrosis in the leaves. After the plant was closed, the company (Cominco American) was sued for damages to cattle by a neighboring rancher. This suit is still undecided. Upon examination, it was apparent that the cattle were indeed fluorotic and the condition was due to the ingestion of grass with the coating of fluoride dust. This dust, though bound in a form which was not assimilated by plants, is changed in the digestive system of the animal into a form which is absorbed, causing fluorosis. Studies now in progress show that rodents within the area are also being poisoned in a similar manner. Deer collected in the vicinity by the Montana Fish and Game Department had excessively high fluoride levels in their bones. Grass and conifer needle samples collected after the winter precipitation showed little if any decline in the total fluorides present, so this vegetation will continue to affect the wildlife in the area for at least another year.

A third case of poisoning by fluoride is occurring at Columbia Falls, Mont. There an aluminum smelter has just recently completed the sixth potline in its electroreduction plant. This smelter is located at the base of a mountain at one end of a valley. The vegetation on Teakettle Mountain began showing necrosis when the first potlines were burned in. This smelter has been in operation about 10 years and with each year the damage to vegetation has increased. Fluorosis of cattle on nearby ranches has been verified by the State veterinarian. Conifer needle, grass, and other vegetation samples were collected in 1968 and all had abnormally high fluoride levels. Grasses and alfalfa levels exceeded the maximum allowed by the State board of health for forage. With the operation of all six potlines this summer, much more extensive damage is anticipated, and a study has been initiated to sample vegetation and wildlife in the vicinity of the smelter, particularly on Teakettle Mountain against which the hydrogen fluoride gases are swept. Accumulation of fluorides in the vegetation with resultant damage and fluorosis of animals accompanied by depletion of wildlife populations is expected. The geographical extent of the damage may be difficult to ascertain until all six potlines have been operating for at least a year. Damage into Glacier Park is expected.

A fourth case of poisoning of the ecosystem due to airborne contaminants is that in East Helena (a suburb of Montana's capital city). In East Helena a lead

smelter has been operating for 80 years. When original complaints of ill effects on animals came in, the American Smelting & Refining Co. installed the abatement equipment then available and the improvement alleviated the damage to the animals on nearby ranches, and presumably to wildlife also. However, in 1967 a change in ore and consequent change in process resulted in the release of tremendous quantities of sulfur dioxide gas from the stack. Vegetation in yards in East Helena literally died overnight, and the State board of health began compiling a file of the complaints about the smelter's fumes. Histological studies and analysis of total sulfur of vegetation were made. Concurrently the State board of health analyzed soil at several locations and the vegetables from a garden across from the smelter for lead, cadmium, arsenic, and zinc. The levels of these heavy metals exceeded in many cases the Federal Food and Drug Administration standards by many times, and studies were immediately begun on the heavy metal content of other vegetable gardens in the area. The FDA allows 3.5 parts per million of lead in foods, and some of the vegetable samples were 20 times this amount. Cadmium is to toxic that no standard has been set as a safe amount in food, yet several parts per million were found in some vegetables. The danger here, of course, is not from one or even an occasional eating of these foods, but from the continuous ingestion of foods of such high levels of heavy metals accompanied by long term continuous inhalation of similarly polluted air. Rabbits being raised near the smelter did not have significantly high levels of lead and cadmium, but one rabbit fed for a month on vegetables from the garden originally sampled accumulated alarmingly high levels of these metals in the liver and kidneys. A young pig and one domestic rabbit running wild were taken from a neighboring farm and analyzed. These two animals also showed that lead and cadmium were accumulating from eating vegetation which had been growing in the area where the stack gases were present. Studies are continuing this summer on damage from sulfur dioxide and accumulation of metals in vegetation. Rodents will be collected in the area for further studies on the accumulation of heavy metals. Testing of the ambient air, soil, and water will also be done this summer, and other animals and humans will be tested for assimilation and accumulation of lead and cadmium.

Studies of these four problem areas in Montana has been hampered by insufficient money to do the work required. Not until the Federal Government stepped in with staff and funds to do the studies was any significant progress made in Garrison, Mont. The State budget for air pollution control will not finance the extensive work needed to ascertain damage to plants, animals, and humans, to discover the actual cause and source of the damage, and to force change upon those responsible for the damage. Until much greater amounts of money become available, studies on the damage to plant and animal life will continue to be peeking to see if the ogre is still there. He will be—and growing larger.

STATEMENT OF DR. CLARENCE C. GORDON, PLANT PATHOLOGIST; PROFESSOR OF BOTANY, UNIVERSITY OF MONTANA, MISSOULA, MONT.; MEMBER, BOARD OF EXPERTS, RACHEL CARSON TRUST FOR THE LIVING ENVIRONMENT

Dr. GORDON. Yes, I will condense it. In fact, there are in addition two full reports. One is the area where there is lead and cadmium and zinc and an arsenic poisoning, a report to the board of health, and the other one is the study where there is an accumulation of fluorides in the vegetation causing crippling of cattle and deer and rodents in the area. I will go through this very briefly.

(The reports referred to, "East Helena Reports on Air Pollution Abatement" and "Cominco American Report," are reprinted in the appendix of this hearing record, on p. 238 and p. 242, respectively.)

One thing I would like to say about Dugway: I have talked to my colleagues down there and there is no individual in the Center of Environmental Biology at the University of Utah who carried on research on the vegetation in the Dugway area—independent research,

which I think is always very important; to have an independent researcher carry out the research instead of someone with a vested interest.

In Garrison, there was an accumulation of fluorides in the vegetation. The animals—in this particular case, a lot of cattle—became crippled and this upset farmers so the court action occurred and HEW came in and helped to settle this problem.

With regard to the ecosystem, the animals were affected as far as 10 miles away from the source. It was a long period of accumulation. Sometimes plants don't show the effects but they do accumulate fluorides. The ones that die, you know there has been an effect, but the grasses accumulate very high concentrations of fluorides without showing any effect. The animal eats the vegetation and accumulates tremendous quantities of fluorides.

For instance, one rabbit we shot—the only one we shot, I might add—within a 4-mile radius of the plant had 16,000 parts per million in it. Cows usually die at around 8,000 or 9,000 parts per million.

In Columbia Falls, the case is again the same thing; hydrogen fluoride. The only reason it is interesting is because I believe it will be affecting Glacier National Park this year and maybe we will get some action.

When the people from Dugway were talking about Dugway, I noted the same political problems we had there are similar in the local and State governments in our areas, too, where people don't like to talk about situations until they are very serious.

For instance, the area being damaged around Columbia Falls is U.S. Forest Service and Department of Interior land and the facts of life are that this plant has an eight and a half million dollar payroll and very few people talk; yet the whole mountain is dying from fluorides. The problem may be similar to what one of the Congressmen had talked about.

In East Helena is the most serious problem. We fed animals from the vegetable gardens growing in East Helena and, due to a lack of money, did not do a lot of research. There was a tremendous buildup of lead and cadmium, causing serious problems to humans and animals.

I studied animals due to the fact that there were litter abortions in rabbits in the area. Several people raised rabbits and noted a lot of abortion of their litters. I started a study and collected animals besides noting the obvious damage from sulfur dioxide. Lead and cadmium, are very insidious types of poisons that accumulate over a long period of time.

The soil in this area has high concentrations of metals. So have the vegetables and so have the animals that feed upon this vegetation. By the way, the Department of Health, Education, and Welfare is coming into this area this summer, I hope, and will conduct a study.

I hope I kept this to a minimum. I am sure I passed up a lot of things but I wanted to make it brief. I know you want to get up and stretch.

Mr. REUSS. We are very grateful to both of you. Between you, you represent plants and animals, I guess. Have both of you had the opportunity to hear the testimony throughout the day of witnesses who had especially to do with Dugway? Yes, all right.

I guess I will just ask both you gentlemen the following question: Do you see dangers to the ecosystem both with respect to wildlife, not-

ing the presence of wildlife refuges very close to the Dugway area, and with respect to plant life? Do you sense any dangers to the ecology as a result of the Army testing of agents at Dugway as it has been characterized to date?

Dr. GORDON. Yes. First, there is absolutely no information about the accumulation in vegetation. I was working on air pollution for the last 10 years and I know you have to control it at the source. You can control it nowhere else. You must control the chemical at the source. Stop it right there.

Therefore, if you test these, you have to test them in enclosed units. You cannot let them out into the environment at all.

I think there is a lot of danger, but I think the biggest danger is not biological; I think it is political in this particular area.

Mr. REUSS. Mr. Keith?

Mr. KEITH. Certainly, as I stated, all applications of toxic chemicals—I stated pesticides, but of toxic chemicals also—pose a hazard. In our investigations, we have been able to identify some of these effects on wildlife. Undoubtedly, in this case there also are effects.

Dr. GORDON. I would like to say one thing. I have been quite aware of Dugway. In fact, Dr. Osguthorpe showed his movie the first time at the University of Montana at our request, so we have been aware of this for a long time and we have kept all the clippings and information out of Dugway in our library, and it is a serious situation.

Mr. REUSS. Mr. Hicks?

Mr. HICKS. I have no questions.

Mr. REUSS. Mr. Carlson?

Mr. CARLSON. No questions.

Mr. REUSS. Mr. Indritz?

Mr. INDRITZ. No questions.

Mr. REUSS. Mr. Keith and Dr. Gordon, we are very grateful to you for your contribution.

The subcommitte will now stand adjourned until 10 o'clock tomorrow morning in this room for a continuation of our hearing into possible effects on the environment of open-air testing by the Army at Dugway.

(Whereupon at 4:07 p.m., the subcommittee recessed, to reconvene at 10 a.m., Wednesday, May 21, 1969.)

ENVIRONMENTAL DANGERS OF OPEN-AIR TESTING OF LETHAL CHEMICALS

WEDNESDAY, MAY 21, 1969

HOUSE OF REPRESENTATIVES,
CONSERVATION AND NATURAL
RESOURCES SUBCOMMITTEE
OF THE COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C.

The subcommittee met at 10 a.m. in room 2203, Rayburn House Office Building, Hon. Henry S. Reuss (chairman of the subcommittee) presiding.

Members present: Representatives Henry S. Reuss, Guy Vander Jagt, and Gilbert Gude.

Staff members present: Phineas Indritz, subcommittee chief counsel; Mrs. Edna Gass and Gerald S. Schatz, subcommittee professional staff members; James A. Lanigan, general counsel, and J. P. Carlson, minority counsel, Committee on Government Operations.

Mr. REUSS. Good morning. The Subcommittee on Conservation will be in order for further inquiry into environmental pollution at Dugway Proving Ground, Utah.

I have a letter dated today from our colleague, Congressman Sherman Lloyd, which, without objection we will place in the record.

Mr. VANDER JAGT. I'm familiar with the letter. No objection.

(The letter referred to appears on p. 25.)

Mr. REUSS. We will hear first from the Army—Dr. K. C. Emerson, Acting Deputy Assistant Secretary of the Army (Research and Development), accompanied by Dr. Mortimer A. Rothenberg, Scientific Director, Deseret Test Center, and Brig. Gen. William W. Stone, Director of Materiel Requirements, Army Materiel Command.

Would you three gentlemen come forward, please?

Mr. REUSS. I'm going to ask that you be sworn in. Would you raise your right hands, please?

(Whereupon, Dr. K. C. Emerson, Dr. Mortimer A. Rothenberg, and Brig. Gen. William W. Stone were sworn by the chairman and testified as follows:)

Mr. REUSS. Dr. Emerson, you have a prepared statement, do you not?

Dr. EMERSON. Yes, I do.

Mr. REUSS. Without objection and under the rule it will be admitted into the record.

(Dr. Emerson's prepared statement follows:)

PREPARED STATEMENT OF DR. K. C. EMERSON, ACTING DEPUTY ASSISTANT SECRETARY OF THE ARMY (RESEARCH AND DEVELOPMENT)

Mr. Chairman and members of the subcommittee, Dugway Proving Ground was established by the U.S. Army in February 1942 after detailed study by a committee for the Chief of the Chemical Warfare Service of various potential sites which, because of area, isolation, geography, sparsity of animal and human population, provided the necessary security and safety for the testing of chemical-biological (CB) items. The proving ground was closed at the end of World War II.

Upon the reactivation of the proving ground in 1950 the chief chemical officer established a committee of non-Department of Defense scientists to review the test program at Dugway Proving Ground. This committee met at Dugway Proving Ground to review the test program, consider the scope of testing, technological and safety aspects, and to recommend to the chief chemical officer the safety program to be implemented and the limitations to be imposed on the scope of the testing. The committee met annually through December 1953 and established the protocol under which testing could be accomplished with such agents as chlorine, mustard, lewisite, hydrogen cyanide, phosgene, GA, GB, and certain volatile mixtures.

Prior to initiation of testing with the nerve agent VX, a technological and safety program was initiated in 1956 and conducted during 1957, which upon approval by the chief chemical officer, led to testing of artillery munitions filled with this material. As experience was gained and as the necessary safety and meteorological information was obtained, the scale of testing with VX munitions was increased to the point that a complete spray tank/aircraft system could be tested.

The total CB program, including the test requirements and the capability for CB testing, was reviewed in 1959 by a Department of Defense Ad Hoc Biological and Chemical Group chaired by Dr. A. H. Wilcox, Deputy Director, Defense Research and Engineering. Members included representatives of the President's Science Advisory Commitee, Office of the Special Assistant to the President for Science and Technology, the Defense Science Board, the Office of the Director of Advance Research Projects Agency and of the Army, Navy, and Air Force.

In 1962, the chief chemical officer established a committee to review the total Department of Defense CB program in accordance with the DOD Project 112 study. Included in this study was a complete review of testing aspects of the CB program.

The procedure followed then was that test plans prepared by Dugway Proving Ground were submitted to higher echelons for formal review and approval prior to implementation. With the reorganization of the Army in 1962, and the establishment of the Army Test and Evaluation Command, a similar procedure has been followed. Prior to the initiation of a new type of test or the expansion of the scope of a test wherein potential hazards to either participating personnel or to the surrounding animal or human populations might exist, simulant evaluation and safety studies are instituted to assure reduction of potential hazards to an absolute minimum.

Following the incident of March 13, 1968, involving sheep in Skull Valley, Utah, the Secretary of the Army convened an interagency ad hoc advisory committee to review testing of chemical agents and munitions at Dugway Proving Ground. The committee spent a great deal of time examining all aspects of safety at Dugway Proving Ground and in November 1968 submitted their report to the Secretary of the Army. Copies of that report were provided to you last week.

The Secretary of the Army approved all of the recommendations made by the committee. Implementation of some recommendations actually began before the report was completed. All limitations on testing recommended by the committee are still being observed.

Open-air testing is necessary to validate predictions of capabilities concerning movement, dilution, and deposition of agents.

Through open-air testing we obtain data which is needed to validate or change predictions. Thus, the results of each test improve our ability to evaluate future defensive and weapons systems.

Before toxic agents are tested in the open air, chamber, and simulant open-air test data are obtained and analyzed to aid in establishing and understanding—

(*a*) Basic dissemination and functional characteristics of prototype hardware.

(*b*) Geometric dimensions of agent clouds, particle size distribution, and source strength efficiencies for prototype hardware.

(*c*) Hazard-area dimensions downwind of agent source (safety studies).

(*d*) Casualty production estimates and area coverage capabilities in populated areas.

(*e*) Downwind transport of agent clouds in a broad range of environments to permit generalization of data provided by toxic tests.

Since a variety of agents are employed in chemical weapon systems, a multiplicity of nontoxic chemicals must be developed to evaluate all these systems with simultant payloads. If we consider only one agent, a different chemical is required to simulate each physical characteristic of importance to the effects being investigated (such as contamination density, particle size, vapor hazard, persistence, et cetera). Some chemicals partially fulfill these requirements; however, simultants currently available are of limited usefulness because only a single significant property of the toxic agent can be provided by the substitute. In addition, prior to acceptance and utilization of chemicals simulating a toxic chemical agent, concurrence of cognizant medical authorities must be obtained if exposure of test personnel is anticipated. Intensive investigations to develop broad-range chemical agent simulants are in progress and if successful will be employed in the field and will reduce the number of tests with toxic agent fills.

Open-air toxic agent testing is essential under a number of circumstances in order to establish—

(*a*) Agent characteristics when exposed to the natural environment (agent stability and toxicity relationships).

(*b*) Source strength efficiencies and particle size distributions with prototype hardware and in standardized munitions with new payloads.

(*c*) Final proof of the efficacy of the weapons system in meeting the established military and technical characteristics and in confirmation of predictions derived from simultant testing prior to certification for procurement.

(*d*) Stockpile-to-target sequence when the weapons system cannot be modified to accept a simultant fill, because of service requirements.

(*e*) Capability of protective systems to meet military and technical characteristics when challenged by an agent cloud in the operating environment.

(*f*) Capability of weapons systems and demonstration of effectiveness of agent payload where physiological sampling is essential for technical evaluation.

Since you asked specifically about persistent toxic chemical agents, I will discuss the safety measures taken for open-air testing of VX.

Before field testing of VX-filled munitions was initiated by Dugway Proving Ground in fiscal year 1957, toxic effects of the agent on human beings had been determined for both inhalation and percutaneous methods of exposure. Essential precautions to prevent exposure of personnel to hazardous quantities of VX were established (safety procedures, wearing of protective clothing, et cetera) as well as necessary therapeutic measures in the unusual event of accidental exposure (medical assistance, atropine, et cetera).

Animal studies had been conducted on a variety of laboratory animals (pigeons, canaries, mice, guinea pigs, rats, monkeys, dogs, pigs, goats, cattle, et cetera) so that the physiological effects of VX on these species was known.

An extensive ecology program was established upon the reactivation of Dugway Proving Ground, in the early 1950's. Data had been obtained on the abundance, habitat, living patterns, breeding and migration characteristics of each species of bird and mammal known to occur in the area. A regular schedule for animal and bird surveys, including trapping, has been continued since fiscal year 1952 for the proving ground and surrounding environs. These surveys indicate no impact on the ecological environment of the proving ground area because of testing at Dugway Proving Ground. Studies on the effects of nerve agents have been conducted on native animals (rabbits and rodents) and birds (pigeons). These studies have provided base line data on the effects of nerve agents on the tested species.

After the incident of March 1968, it was apparent that we had no data on the effects of VX on range sheep. This was because toxicity data from sheep are not readily extrapolated to man. The laboratory animals tested are those normally used in investigations of the toxicity of chemicals. Since that time range sheep were fed traces of nerve agent, to determine the effect of trace quantities of VX

in producing lethalities and on the inhibition of cholinesterase activity. Experiments were completed at several oral dose levels to establish valid toxicity values. Synergistic and/or additive effects of VX in combination with heptachlor and other insecticides were investigated, and no increase in activity of various combinations could be demonstrated.

Concurrent with these experiments, it was demonstrated that trace amounts of VX were present in the browse where the sheep died, but in quantities not considered sufficient to have produced the observed physiological effects. In our experiments we have not been able to duplicate some of the physiological effects observed in the range animals in Skull Valley in March 1968. The immediate problem was to determine if the range was safe. The safety of the vegetation on ranges surrounding the proving ground for browsing animals was demonstrated by grazing 36 sentinel cows and 94 sheep in these areas. Based on the results of the grazing studies and forced feeding experiments conducted cooperatively with the USDA Agricultural Research Service and verified repetitively, the Bureau of Land Management, in October 1968, declared the range safe for the grazing of livestock.

Toxicology studies with cattle, horses, pregnant sheep (including lambs), and major native rodent species have been initiated. Results of these studies will be available in fiscal years 1969 and 1970.

Since March 1968, no aerial spray tests of persistent lethal agents have been conducted. Within the limitations recommended by the committee, and adopted by the Army, five open air tests with the 8-inch howitzer shell VX filled (14.5 lb/round) have been conducted. On each of these trials one shell was functioned at 50 feet above the terrain. Also four trials have been conducted, in each of which 17 pounds of agent was released from a boom at 18 feet above the terrain. The boom was a test device to release agent in drop sizes of from 100-500 microns for downwind transport studies and grid calibrations.

In support of the toxic agent open-air test program, an accident/incident control plan (including mass casualty and medical evacuation procedures) was revised and tested. Utah State health and local officials participated in the planning and exercise of this plan.

The Governor of the State, Utah State Director of Health and other officials of the State of Utah, are given regular periodic briefings on all planned testing at the proving ground.

A permanent Chemical Safety Committee to provide expert, independent, non-Defense Department advice on safety of the open-air testing program has been established. This committee provides advice to the commanding general of the Deseret Test Center, the parent organization of Dugway Proving Ground.

The Chemical Safety Committee includes:

Dr. Jake T. Nolen, chairman, Wilmington, Del.

Dr. Louis C. LaMotte, Jr., National Communicable Disease Center, U.S. Public Health Service, Atlanta, Ga.

Dr. James B. DeWitt, Assistant Chief, Division of Pesticides Registration, Bureau of Sport Fisheries and Wildlife, Department of Interior.

Dr. Warren C. Shaw, assistant to the director, Crops Research Division, Department of Agriculture.

Dr. Lester Machta, director, Air Resources Laboratories, Environmental Sciences Services Administration, Department of Commerce.

Dr. J. Henry Wills, associate director, Institute of Experimental Pathology and Toxicology, Albany Medical College of Union University, Albany, N.Y.

Dr. G. D. Carlyle Thompson, director of health, Utah State Department of Health, Salt Lake City, Utah.

The functions of the Chemical Safety Committee are:

1. To review and analyze Deseret Test Center programs in meterology, test technology, plant and animal physiology, toxicology, and safety procedures.

2. To examine the immediate and residual hazards to man, wildlife, and domestic animals, and plants, on and off test sites, as related to test activities.

3. To analyze and identify knowledge gaps in the Deseret Test Center test program, actions, safety criteria and procedures required for the safe conduct of chemical test activities with toxic and incapacitating agents and weapons systems.

Existing restrictions on testing will remain in effect until the Chemical Safety Committee recommends changes which are approved by intermediate commands and the Secretary of the Army. The intermediate commands will review the

changes and make appropriate recommendations, but no changes will occur unless the Secretary of the Army concurs.

All available data, classified and unclassified, are provided to the committee so that they can consider all aspects of the program and give their best scientific and technical opinions.

The extension of Deseret Test Center capabilities for detection of the immediate presence and/or verification of the absence of agents in areas outside of selected test grids has been given primary emphasis. Facets of the monitoring system are:

1. Provision of appropriate instrumentation for collection of agents (especially in low concentrations with high volume, chemiluminescent, HYFED, and GC detectors).
2. Development and/or adaptation of methods for determination of trace amounts of selected agents (VX) and potential toxic decomposition products (mass spectrograph. microtec chromatograph, thin layer chromatograph, nuclear magnetic resonance spectrograph, piezoelecrtic crystal agent penetration detector).
3. Establishment of monitoring stations outside of the proving ground boundaries.
4. Monitoring changes in the native animal population.
5. Establishment of flocks of sentinel animals (sheep).

A complementary effort includes periodic visits of competent veterinarians to ranchers or farmers in the surrounding area to reassure people as to the health of their animals.

An expansion of the meteorological network around and on Dugway Proving Ground has been initiated to improve prediction of the movement, dilution, and deposition of toxic clouds released into the atmosphere. Approximately 15 fixed and 15 mobile stations, tied in with a control central will be available for use. (Eight mobile and six fixed stations are presently available to the test network.) A weather radar (MPS–34) has been received on a temporary loan basis from U.S. Army Electronics Command, Fort Monmouth, N.J. An FPS–77 weather radar has been obtained from the U.S. Air Force. Tie-in has been effected with the Federal Aviation Authority and U.S. Weather Radar Service to provide radar plots of meteorological turbulence patterns 12 times per day. A feasibility study concerning the use of optical and radar tracking techniques to obtain information on cloud behavior is being conducted. Contract efforts have been initiated to provide data on travel of intermediate aerosols (10 to 100 microns) and on aerosol washout by rain or snow.

An extensive program related to the meteorological aspects of CB operations, initiated in 1953, is being continued to improve and update the theoretical basis on cloud transport, dilution, and deposition.

In summary, the Army sought advice from a committee of experts and has accepted their recommendations. Periodically, progress reports on implementation of these recommendations will be made to the Secretary of the Army. These reports will be issued in the same manner as the interagency ad hoc committee report. We will continue to employ the scientific resources of the Department of Defense and to seek outside advice to insure that our chemical testing program is conducted in the safest manner possible.

Mr. Reuss. Will you now proceed in your own way? Read it or summarize it as you see fit.

Dr. Emerson. I will summarize it, sir.

STATEMENT OF DR. K. C. EMERSON, ACTING DEPUTY ASSISTANT SECRETARY OF ARMY (RESEARCH AND DEVELOPMENT); ACCOMPANIED BY DR. MORTIMER A. ROTHENBERG, SCIENTIFIC DIRECTOR, DESERET TEST CENTER; AND BRIG. GEN. WILLIAM W. STONE, DIRECTOR OF MATERIEL REQUIREMENTS, ARMY MATERIEL COMMAND

Dr. Emerson. Mr. Chairman and members of the subcommittee, Dugway Proving Ground was established by the U.S. Army in February 1942 after detailed study of various potential sites which,

because of area, isolation, geography, and sparsity of animal and human population, provided the necessary security and safety for the testing of chemical and biological items. The proving ground was closed at the end of World War II.

Upon the reactivation of the proving ground in 1950 a committee of non-Department of Defense scientists reviewed the test program and established the protocol under which testing could be accomplished for such agents as chlorine, mustard, lewisite, hydrogen cyanide, phosgene, GA, GB, and certain volatile mixtures.

Prior to the initiation of testing VX, a technological and safety program was initiated in 1956 and conducted during 1957, which led to testing of artillery munitions filled with this material. As experience was gained and as the necessary safety and meteorological information was obtained, the scale of testing was increased to a complete spray tank/aircraft system.

The total CB program, including the test requirements of the capability for CB testing, was reviewed in 1959 by a Department of Defense ad hoc committee chaired by Dr. Wilcox, the Deputy Director of Defense Research and Engineering. The members included representatives of the President's Science Advisory Committee, Office of the Special Assistant to the President for Science and Technology, the Defense Science Board, the Office of the Director of Advance Research Projects Agency, the Army, Navy, and Air Force.

In 1962, the committee reviewed the total Department of Defense CB program including testing.

The procedure followed then was that test plans were submitted to higher echelons for formal review and approval prior to implementation. Prior to the initiation of a new type of test or the expansion of the scope of a test, wherein potential hazards to either participating personnel or to the surrounding animal or human populations might exist, a similar evaluation and safety studies was instituted to assure reduction of potential hazards to an absolute minimum.

Following the incident of March 13, 1968, the Secretary of the Army convened an interagency ad hoc advisory committee to review testing of chemical agents and munitions at Dugway Proving Ground. The committee in November 1968 submitted their report to the Secretary of the Army. Copies of this report were provided to you last week.

The Secretary of the Army approved all of the recommendations made by the committee. Implementation of some of these recommendations actually began before the report was completed. All limitations on testing recommended by the committee are still being observed.

Open-air testing is necessary to validate predictions of capabilities concerning movement, dilution, and deposition of agents.

Through open-air testing we obtain data which is needed to validate or change predictions. Thus, the results of each test improve our ability to evaluate future defensive and weapons systems.

Before toxic agents are tested in the open air, chamber and simulant open-air test data are obtained and analyzed to aid in establishing and understanding:

(*a*) Basic dissemination and functional characteristics of prototype hardware.

(*b*) Geometric dimensions of agent clouds, particle size distribution and source strength efficiencies for system evaluation.

(*c*) Hazard-area dimensions downwind of agent source.

(*d*) Casualty production estimates and area coverage capabilities.

(*e*) Downwind transport of agent clouds in a broad range of environments to permit generalization of data provided by toxic tests.

Since a variety of agents are employed in chemical weapon systems, a multiplicity of nontoxic chemicals must be developed to evaluate all these systems with simulant payloads. If we consider only one agent, a different chemical is required to simulate each physical characteristic of importance to the effects being investigated—such as contamination density, particle size, vapor hazard, persistence, et cetera. Some chemicals partially fulfill these requirements; however, simulants currently available are of limited usefulness because only a single significant property of a toxic agent can be provided by the substitute.

In addition, prior to acceptance and utilization of chemicals simulating a toxic chemical agent, concurrence of cognizant medical authorities must be obtained if exposure of test personnel is anticipated. Intensive investigations to develop broad-range chemical agent simulants are in progress and if successful will be employed in the field and will reduce the number of tests with toxic agent fills.

Open-air toxic agent testing is essential under a number of circumstances in order to establish: (*a*) agent characteristics when exposed to the natural environment; (*b*) source strength efficiencies and particle size distributions with prototype hardware and in standardized munitions with new payloads; (*c*) final proof of the efficacy of the weapons system in meeting the established military and technical characteristics and in confirmation of predictions derived from simulant testing prior to certification for procurement; (*d*) stockpile-to-target sequence when the weapons system cannot be modified to accept a simulant fill, because of service requirements; (*e*) capability of protective systems to meet military and technical characteristics when challenged by an agent cloud in the operating environment, and (*f*) capability of weapons systems and demonstration of effectiveness of agent payload where physiological sampling is essential for technical evaluation.

Since you asked specifically about persistent toxic chemical agents, I will discuss the safety measures taken for open-air testing of VX.

Before field testing of VX-filled munitions was initiated by Dugway Proving Ground in 1957, toxic effects of the agent on human beings had been determined for both inhalation and percutaneous methods of exposure. Essential precautions to prevent exposure of personnel to hazardous quantities of VX were established (safety procedures, wearing of protective clothing, and so forth), as well as necessary therapeutic measures in the unusual event of accidental exposure—medical assistance and atropine, and so forth.

Animal studies have been conducted on a variety of laboratory animals—pigeons, canaries, mice, guinea pigs, rats, monkeys, dogs, pigs,

goats, cattle, et cetera, so that the physiological effects of VX on these species were known.

An extensive ecology program was established upon the reactivation of Dugway Proving Ground, in the early 1950's. Data has been obtained on the abundance, habitat, living patterns, breeding and migration characteristics of each species of bird and mamal known to occur in the area. A regular schedule for animal and bird surveys, including trapping, has been continued since 1952 for the proving ground and surrounding environs. These surveys indicate no impact on the ecological environment of the proving ground area because of testing at Dugway Proving Ground. Studies on the effects of nerve agents have been conducted on native animals (rabbits, rodents, and birds). These studies have provided baseline data on the effects of nerve agents on the tested species.

After the incident of March 1968, it was apparent that we had no data on the effects of VX on range sheep. This was because toxicity data from sheep are not readily extrapolated to man. The laboratory animals tested are those normally used in investigations of the toxicity of chemicals. Since that time range sheep were fed traces of nerve agent, to determine the effect of trace quantities of VX in producing lethalities and on the inhibition of cholinesterase activity. Experiments were completed at several oral dose levels to establish valid toxicity values. Synergistic and/or additive effects of VX in combination with heptachlor and other insecticides were investigated, and no increase in activity of various combinations could be demonstrated.

Concurrent with these experiments, it was demonstrated that trace amounts of VX were present in the browse where the sheep died, but in quantities not considered sufficient to have produced the observed physiological effects. In our experiments we have not been able to duplicate some of the physiological effects observed in the range animals in Skull Valley in March 1968. The immediate problem was to determine if the range was safe. The safety of the vegetation on ranges surrounding the proving ground for browsing animals was demonstrated by grazing 36 sentinel cows and 94 sheep in these areas.

Based on the results of the grazing studies and forced feeding experiments conducted cooperatively with the USDA Agricultural Research Service and verified repetitively, the Bureau of Land Management, in October 1968, declared the range safe for the grazing of livestock.

Toxicology studies with cattle, horses, pregnant sheep (including lambs), and major native rodent species have been initiated. Results of the studies will be available in fiscal year 1969 and fiscal year 1970.

Since March 1968, no aerial spray tests of persistent lethal agents have been conducted. Within the limitations recommended by the committee, and adopted by the Army, five open-air tests with the 8-inch howitzer shell VX filled have been conducted. On each of these trials one shell was functioned at 50 feet above the ground. Also four trials have been conducted, in which 17 pounds of agent were released from a boom at 18 feet above the terrain. The boom was a test device to release agent, in drop sizes of from 100 to 500 microns, for downwind transport studies and grid calibrations.

In support of the testing program, an accident/incident control plan has been revised and tested. Utah State health and local officials participated in the planning and exercise of this plan.

The Governor of the State of Utah, Utah State Director of Health and other officials of the State, are given periodic briefings on all planned testing at the proving ground.

A permanent safety committee to provide expert, independent, non-Defense Department advice on safety of the open-air testing program has been established. The members of the committee are listed, and the functions of the committee are in the longer statement.

Restrictions on testing will remain in effect until the Chemical Safety Committee recommends changes which are approved by intermediate commands and the Secretary of the Army. The intermediate commands will review the changes and make appropriate recommendations, but no changes will occur unless the Secretary of the Army concurs.

All available data, classified, and unclassified, are provided to the committee so that they can consider all aspects of the program and give their best scientific and technical opinions.

The extension of Deseret Test Center capabilities for detection of the immediate presence, and/or verification of the absence of agents, in areas outside of selected test grid areas has been given primary emphasis. Facets of the monitoring system are:

1. Provision of appropriate instrumentation for collection of agents (especially in low concentrations with high volume, chemiluminiscent, HYFED, and GC detectors).
2. Development and/or adaptation of methods for determination of trace amounts of selected and potential toxic decomposition products.
3. Establishment of monitoring stations outside of the proving ground boundaries.
4. Monitoring changes in the native animal population.
5. Establishment of flocks of sentinel sheep.

A complementary effort includes periodic visits of competent veterinarians, to ranchers or farmers in the surrounding area, to reassure people as to the health of their animals.

An expansion of the meteorological network around and on Dugway Proving Ground has been initiated to improve prediction of the movement, dilution, and deposition of toxic clouds released into the atmosphere. Approximately 15 fixed and 15 mobile stations, tied in with a control central, will be available for use. A weather radar has been received on a temporary loan basis from U.S. Army Electronics Command. An FPS–77 weather radar has been obtained from the U.S. Air Force. Tie-in has been effected with the Federal Aviation Authority and U.S. Weather Radar Service, to provide radar plots of meteorological turbulence patterns 12 times per day. A feasibility study concerning the use of optical and radar tracking techniques to obtain information on cloud behavior is being conducted. Contract efforts have been initiated to provide data on travel of intermediate aerosols (10–100 microns), and on aerosol washout by rain or snow.

An extensive program related to the meteorological aspect of CB operations, initiated in 1953, is being continued to improve and update the theoretical basis on cloud transport, dilution, and deposition.

In summary, the Army sought advice from a committee of experts and has accepted their recommendations. Periodic reports on implementation of these recommendations will be made to the Secretary of the Army. These reports will be issued in the same manner as the interagency ad hoc committee report. We will continue to employ the scientific resources of the Department of Defense and to seek outside advice, to insure that our chemical testing program is conducted in the safest manner possible.

Mr. REUSS. Thank you very much.

At pages 10 and 11 of your testimony, you recount the setting up of what you call an independent, non-Defense Department Chemical Safety Committee. You list the members of the committee and their employer in each case for all the seven members with the exception of the first man, Dr. Jake T. Nolen, the chairman, who apparently lives in Wilmington, Del. Who is his employer?

Dr. EMERSON. I think he is employed by Du Pont. These are the mailing addresses.

Mr. REUSS. Yes. Is it not a fact that Du Pont is one of the 50 biggest defense contractors in this country?

Dr. EMERSON. I don't know.

Mr. REUSS. Is it not a fact that Du Pont and its subsidiaries in the current fiscal year have more than $150 million of defense orders?

Dr. EMERSON. I don't know that to be, Mr. Chairman.

Mr. REUSS. Is it not further a fact that Du Pont makes an ingredient of the VX nerve gas agent? Don't they make the dye that is used in it?

Dr. EMERSON. I'm not aware of it.

Mr. REUSS. Well, talk to your friends and let us have an answer.

Dr. ROTHENBERG. Yes, the dye which is used as the tracer material is manufactured by Du Pont.

Mr. REUSS. Is it not further a fact that Du Pont makes defoliant agents that are currently in use in chemical warfare by the U.S. forces?

Dr. ROTHENBERG. I'm not aware of any contract with Du Pont in this case.

Dr. EMERSON. I'm not either.

Mr. REUSS. Your testimony is that they do not make any of the defoliants?

Dr. EMERSON. Our testimony is that we are in the research and development. That would be a logistic function. We are not knowledgeable in that area.

(Subsequently, the Department of the Army advised the subcommittee that "The Department of Defense does not procure defoliants from the Du Pont Co.")

Mr. REUSS. Have one of your people get a witness up here who can be more responsive than you three gentlemen are being. We will reserve that question. I'd like to have him here as soon as possible.

(Subsequently, the Department of the Army submitted the following data to the subcommittee:)

Department of Defense prime contract awards of $10,000 or more with E. I. du Pont de Nemours & Co. and the Remington Arms Co., fiscal year 1968

Item	*Value (in thousands of dollars)*
E. I. du Pont de Nemours & Co.:	
Operation and/or maintenance of ammunition facility	$15,908
Demolition materials	5,639
Photographic supplies	2,739
Land mines	1,659
Gases: Compressed and liquefied	1,069
Chemicals	728
Bulk explosives	712
X-Ray equipment and supplies: Medical, dental, veterinary	718
Fibers: Vegetable, animal, and synthetic	650
Ammunition, through 30 mm	371
Research and development of munitions	220
Cartridge and propellants, actuated devices and components	70
Laboratory equipment and supplies	59
Packaging and packing bulk materials	67
Textile fabrics	22
Pest control agents and disinfectants	16
Dental instruments, equipment and supplies	15
Total	30,662
Remington Arms Co.:	
Operation and/or maintenance of ammunition facility	112,753
Ammunition, through 30 mm	25,661
Miscellaneous special industry machinery	908
Guns, through 30 mm	388
Bombs	147
Ammunition, 75 mm through 125 mm	25
Research and development of weapons	25
Total	139,907
Total, Du Pont and Remington	170,569

Department of Defense prime contract awards of $10,000 or more with E. I. du Pont de Nemours & Co. and the Remington Arms Co., July 1968 to March 1969

Item	*Value (in thousands of dollars)*
E. I. du Pont de Nemours & Co.:	
Explosives, solid propellants, and explosive devices	$8,948
Operation and/or maintenance of ammunition facility	7,479
Chemicals	6,326
Photographic supplies	4,584
X-Ray equipment and supplies: Medical, dental, veterinary	736
Gases: Compressed and liquefied	396
Bulk explosives	329
Miscellaneous chemical specialties	297
Fibers: Vegetable, animal, and synthetic	209
Dyes	68
Physical properties testing equipment	40
Chemical analysis instruments	37
Land mines	14
Combination and miscellaneous testing instruments	26
Total	29,489

Remington Arms Co.:	
Operation and/or maintenance of ammunition facility	146,285
Ammunition, through 30 mm	14,768
Miscellaneous special industry machinery	472
Bombs	121
Guns, through 30 mm	108
Demolition materials	19
Research and development of munitions	14
Total	161,787
Total, Du Pont and Remington	191,276

Mr. REUSS. You stick to your testimony that the Chemical Safety Committee chaired by an employee of Du Pont is an independent non-Defense Department committee?

Dr. EMERSON. I do.

Mr. REUSS. Your position is Assistant for Research, Office of Assistant Secretary of Army (research and development)?

Dr. EMERSON. No; it is Acting Deputy Assistant Secretary.

Mr. REUSS. How long have you held that position?

Dr. EMERSON. Since the 15th of April.

Mr. REUSS. What were you on March 13, 1968?

Dr. EMERSON. Assistant for research.

Mr. REUSS. The same job?

Dr. EMERSON. No. The job you just mentioned I was on.

Mr. REUSS. Yes, right.

Dr. Rothenberg, you are now scientific director, Dugway Proving Ground?

Dr. ROTHENBERG. Deseret Test Center. I was formerly, prior to July 1, 1968, scientific director, Dugway Proving Ground.

Mr. REUSS. On March 13, 1968, you were scientific director of Dugway Proving Ground?

Dr. ROTHENBERG. That's correct.

Mr. REUSS. And General Stone, you are now director of materiel requirements, Army Materiel Command?

General STONE. Yes, sir.

Mr. REUSS. That's not part of the Chemical Warfare Service?

General STONE. No, sir.

Sir, my job is in the requirements area for materiel of all types that the Army uses.

Mr. REUSS. What was your job on March 13, 1968?

General STONE. I was assistant deputy for research and laboratories in the same headquarters.

Mr. REUSS. I will ask this question of Dr. Emerson:

On March 13, 1968, what was the chain of command with respect to the Dugway Proving Ground? I will start it: L. B. J., Commander in Chief; Clark Clifford, Secretary of Defense; and you take it from there.

Dr. EMERSON. The Secretary of the Army, Stanley Resor, through the Chief of Staff who was at that time Gen. Harold K. Johnson, to

the commanding general of the Army Materiel Command, Gen. Frank Besson, to the U.S. Army Test and Evaluation Command, Maj. Gen. Leland Cagwin.

Mr. REUSS. And these are the holders of these positions as of March 13, 1968?

Dr. EMERSON. Yes.

Mr. REUSS. Go on.

Dr. EMERSON. Then the commander of the Dugway Proving Ground, Col. James Watts.

Mr. REUSS. Commander of Dugway Proving Ground.

And how does the Deseret Test Center fit in there?

Dr. EMERSON. It did not at that time. Since then the two organizations have been combined. The Deseret Test Center is a planning organization and the proving ground is the terrain or the area on which the tests are conducted.

Mr. REUSS. And who is the commanding officer of Dugway Proving Ground today?

Dr. EMERSON. The test center is commanded by——

Mr. REUSS. Beg your pardon?

Dr. EMERSON. The test center is commanded by Brigadier General Appel.

Mr. REUSS. And where is Colonel Watts?

Dr. EMERSON. He is at Yuma, Ariz.

Mr. REUSS. Now, we have had testimony that on March 13, 1968, a VX nerve gas test was conducted in the atmosphere and polluted the atmosphere, and it was responsible for the Army's paying more than half a million dollars to the owners of certain sheep which were found dead within the next few days. Is that true or false?

Dr. EMERSON. Yes; it's true.

Mr. REUSS. We also had testimony that on or about March 20, 1968, the public relations officer for Dugway Proving Ground issued a statement saying there has been no VX testing at the Dugway Proving Ground.

Dr. EMERSON. No, sir. The answer which you are quoting was given, but that was not the question which was asked.

Mr. REUSS. Who gave this answer?

Dr. EMERSON. The information officer, but what was asked——

Mr. REUSS. What is his name?

Dr. EMERSON. Colonel Black.

Mr. REUSS. Colonel Black. May we have his full name?

Dr. EMERSON. I beg your pardon, Tom Donnelly.

Mr. REUSS. Is he a civilian?

Dr. ROTHENBERG. Yes.

Mr. REUSS. Tom Donnelly?

Dr. EMERSON. Yes.

Mr. REUSS. And you say the information he gave was that no VX test had been conducted.

Dr. EMERSON. No, sir.

Mr. REUSS. I thought you just testified that he did give that answer but that the question was not as I have stated it.

Dr. EMERSON. That's right.

Mr. REUSS. Well, then, I repeat my question. It is a fact that Mr. Donnelly, the public information officer for Dugway Proving Ground,

on or about March 20, 1968, informed the public that a nerve gas VX test had not been conducted at Dugway?

Dr. EMERSON. The data that I have available to me says that the question that was asked on the 20th was—"Had there been any biological testing," and the answer was: "No, there had not been."

Mr. REUSS. Would you present this committee with the data on which you base that answer? Just bring it up here and let us study it.

Dr. EMERSON. That was by my interview yesterday prior to coming here.

Mr. REUSS. Your interview with whom?

I think, General Stone and Dr. Rothenberg, if either of you gentlemen has any information to give to the subcommittee you will be recognized and given a full opportunity to testify. I don't think we want this mutual coaching of witnesses. I don't think it does credit to the Army.

Would you now respond?

Dr. EMERSON. I asked the question in the last few days, since that statement had been posed to me before; and I got the answer by telephone. I have no written paper to give you to this effect.

Mr. REUSS. Well, what did Mr. Donnelly say with reference to the person to whom he gave this information on March 20? Did he give out a press release or did he answer telephone calls or what?

Dr. EMERSON. I did not talk to Mr. Donnelly.

Mr. REUSS. Well, then, how do you know that Mr. Donnelly did or did not deny that the Army had been conducting outside tests of nerve gas?

Dr. EMERSON. On the terms that you are talking about, I cannot provide you any proof one way or the other. I could, for the record, but I cannot with what I have available to me now.

Mr. REUSS. Congressman McCarthy and others have testified that public relations officer Donnelly on or about March 20, 1968, told the press and the public that the Army had not conducted any tests which could have caused the sheep deaths. Is that true or is that false?

Dr. EMERSON. I cannot say anything further at this time.

Mr. REUSS. Can you enlighten us, General Stone?

General STONE. Sir, if I may, I arrived out at Dugway Proving Ground on the 22d of March, having been designated by General Besson to look into the incident from his point of view as commanding general of the Army Material Command.

I understood that this statement had been made to the press—that is, a statement to the effect that the Army denied responsibility. I looked into it. I never found anything in writing.

My understanding is that the query which was made to Mr. Donnelly by phone by the press and was to the effect—was the Army responsible for the dying sheep on the range? The answer as I understand it that Mr. Donnelly gave at that time was that they were not, and I believe that this was the sense in which the question was asked and answered, to the best of my knowledge.

Mr. REUSS. And where do you get your knowledge from?

General STONE. This was from talking to Mr. Donnelly and talking to the commanding officer when I arrived out there on the 22d of March.

Mr. REUSS. Now, Dr. Rothenberg, there was testimony here yesterday that on March 20 you and the Dugway Proving Ground commander, Colonel Watts, met with people representing the Governor of Utah, notably Dr. Osguthorpe. Is that correct?

Dr. ROTHENBERG. That is correct.

Mr. REUSS. Where was that meeting?

Dr. ROTHENBERG. This was in the Governor's office, as I recall, on the 22d actually, according to our log.

Mr. REUSS. There was a meeting in the Governor's office on March 22. However, 2 days before, on the 20th, according to testimony we had here yesterday, at or near the Dugway Proving Ground, you and Colonel Watts had a conversation with Dr. Osguthorpe. Is that true or false?

Dr. ROTHENBERG. This may very well be so. I don't recall whether it was the 20th. I believe it was the 22d.

Mr. REUSS. The testimony yesterday was that there were two meetings, one in the Governor's office on the 22d and an earlier meeting 2 days before on the 20th, at or near the Dugway Proving Ground.

Dr. ROTHENBERG. Well, if my memory serves me correctly the meeting with Colonel Watts, myself, and the Governor on the 22d—this is as early as I can recall from my notes—was to brief the Governor with respect to the particular incident. And at that particular time, Governor Rampton appointed Mr. Waldron, the commissioner of livestock of Utah State Department of Agriculture, to represent the State.

Mr. Waldron, not being experienced technically, suggested very strongly to the Governor that Dr. Osguthorpe be appointed in his stead to act as the State's technical representative. This is, as well as I can reconstruct, the sense of that particular discussion.

Mr. REUSS. Yes. You have answered a question which I did not put. I'm not concerned about the meeting on March 22 in the Governor's office. I'm concerned about the meeting on or near the Dugway Proving Ground 2 days before, on March 20, at which were present, according to testimony we had yesterday, Dr. Osguthorpe and yourself and Colonel Watts.

Did such a meeting take place or did it not?

Dr. ROTHENBERG. I do not recall specifically whether or not it did.

Mr. REUSS. There was further testimony that at such a meeting you told Dr. Osguthorpe that the Army had not tested VX since the preceding July. That would be July 1967. True or false?

Dr. ROTHENBERG. This is false.

Mr. REUSS. Did you make any statements to Dr. Osguthorpe about that?

Dr. ROTHENBERG. The main question raised at that particular time was related to the possibility of a biological material having escaped the proving ground and affected the sheep, and this discussion—in that particular time frame—was our greatest concern.

Mr. REUSS. What do you mean by time frame?

Dr. ROTHENBERG. From the 13th to the 20th—in that particular week.

Mr. REUSS. And what was the discussion?

Dr. ROTHENBERG. I'm sorry but I don't keep detailed appointment calendars on hand for more than a year.

Mr. REUSS. Well, do you categorically deny under oath ever telling anybody that the Army had not tested VX nerve gas since July 1967?

Dr. ROTHENBERG. Will you repeat the question, please?

Mr. REUSS. Do you deny—and I remind you, you are under oath——

Dr. ROTHENBERG. Yes.

Mr. REUSS (continuing). Telling anybody at any time that the Army had not tested—you will do better in answering this if you will listen to the question—do you deny telling anybody at any time that the Army had not tested VX nerve gas in the open air during the period from July 1967 to March 1968?

Dr. ROTHENBERG. That's a rather broad question.

Mr. REUSS. Well, I will try again.

There was testimony yesterday by Dr. Osguthorpe that on March 20, 1968, on or very close to the Dugway Proving Ground, when he made his first reconnaissance over there, he visited with you and the base commander, Colonel Watts. Dr. Osguthorpe further testified that both you and Colonel Watts, in response to his inquiry, told him that it could not have been VX that killed those sheep because the Army had not tested VX since July 1967, in the open air. True or false?

Dr. ROTHENBERG. I don't think that's—I don't know how to answer that.

Mr. REUSS. What was you answer?

Dr. ROTHENBERG. I cannot deny that I did not tell anybody—I think it is such a broad question that it is almost impossible to answer.

Mr. REUSS. In fact the Army did test VX gas in the open air on March 13, 1968, did it not?

Dr. ROTHENBERG. In fact the Army did test VX on March 13th, yes.

Mr. REUSS. Did you tell anybody publicly or privately anything inconsistent with that, anything which might lead that person to believe that the Army had not conducted open-air tests?

Dr. ROTHENBERG. Not to my knowledge.

Mr. REUSS. Did you tell Dr. Osguthorpe that the Army had tested——

Dr. ROTHENBERG. No. No, I did not.

Mr. REUSS (continuing). VX on March 13?

Dr. ROTHENBERG. No, I did not tell Dr. Osguthorpe that the Army had tested. There are security matters related to this whole area and I don't believe that one goes freely about telling any individual all information with respect to activities at the proving ground.

Mr. REUSS. Dr. Osguthorpe was the veterinary specialist representing the Governor of Utah, was he not?

Dr. ROTHENBERG. He was appointed on the 22d. As far as we were concerned, if he was there on the 20th—and I don't recall that he was—he was acting solely on the part—of the ranchers involved and as a private consultant to the ranchers.

Prior to giving him access to the information with respect to the proving ground activities a security check was made and he was provided with interim clearance by the commanding officer of Dugway Proving Ground. This did not occur until after the 22d.

Mr. REUSS. Do you think that VX testing on March 13 could conceivably could have had something to do with the death of those 6,000 sheep?

Dr. ROTHENBERG. Yes, I do.

Mr. REUSS. Dr. Osguthorpe testified yesterday that had he and other competent veterinary scientists been informed of the existence of the VX test promptly after the test itself they might, by the administration of atrophine, have been able to save the great preponderance of those sheep.

In the light of that, do you think it was in the public interest for you to withhold information that Dugway Proving Ground had in fact been conducting VX tests, and then to pay more than half a million dollars of taxpayers' money to sheepowners for sheep that died through the inability of veterinarians to prescribe atrophine because they didn't know what the cause of death was?

Dr. ROTHENBERG. Sir, it is quite possible that the sheep might have been saved had we been informed in time of the occurrence in the valley. We were not informed until the 17th of March, on Sunday, of the possibility of some epidemic spreading through the valley.

This was how it was put to us. It was Sunday, the 17th of March. Therapy might have been quite useful had it been applied within a day of the particular incident, but there was a 4-day lapse before we even got a glimmer of what the situation was in Skull Valley. We were not officially actually informed until Monday, the 18th of March.

Mr. REUSS. Congressman Lloyd of Utah, the very alert Congressman representing that area, states that he was informed immediately and almost immediately came out to Utah to look into it. How come you were asleep at the switch for 4 days?

Dr. ROTHENBERG. I resent the statement somewhat, sir. We were not asleep at the switch. We have constant liaison with the ranchers in the valley.

The concern of the rancher at that particular time was for the possibility of some epizootic disease of bacterial or viral origin originating in the valley and spreading through it. We were not alerted, as I say, until Sunday, the 17th, and actually had a visit from the rancher on the 18th telling us what his situation was.

Mr. REUSS. Well, on the 17th when finally you were informed that these sheep were dead or dying—which everybody else seems to have known about—did you then come clean and tell everyone that you had been conducting a nerve gas test in the open air?

Dr. ROTHENBERG. No, sir. Our concern there was for viral or bacterial material which may have——

Mr. REUSS. But our concern, the concerns of this subcommittee and of the American people, are for the total environment, and I would have thought that it was the job of the U.S. Government to fight pollution instead of creating it.

Now how about your broadening your concerns a little bit.

Dr. ROTHENBERG. I think there was no direct relationship foreseen—or direct involvement foreseen at that particular time. There were many instances of viral or bacterial organisms of unknown origin infesting or invading the herds in the State, and this was simply as originally seen by the rancher.

It was originally considered to be just another one of these phenomena until such time as a larger and larger number of animals were becoming more heavily involved. It was at that point that we were

alerted. Prior to that they felt that they could handle it themselves with their own veterinarian service and veterinarian assistance.

Mr. REUSS. Are you trying to tell this committee and the American people that you could spew nerve gas over a wide section of Utah on March 13, and yet when the sheep began to die a few days later it never occurred to you that possibly the nerve gas might have done them in?

Dr. ROTHENBERG. Sir, we have had many, many years of experience in this type of activity. We have been able to confine the material to the proving ground. There are some 15 years of experience with similar systems, similar agents. The material has never in the past escaped from the proving ground and our basic feeling here was that essentially it had been confined to the area in which it had been tested.

The bulk of the material should come down within 1 mile of the spray line and to even consider ourselves as having been involved in an incident which occurred 30 miles away was rather inconceivable at that particular time.

Mr. REUSS. Doctor, you frighten me. You really do.

Who gave you your authority to spew these poisons all over the environment? Who told you to do that?

Dr. ROTHENBERG. The program in which we are involved is a recognized, authorized program of the Department of Army, supervised by a number of advisory committees from the safety standpoint, to establish safety procedures which have been employed for a rather extended period of years and have been proven quite adequate in controlling the situation at the proving ground and the testing.

Mr. REUSS. What is the amount in this year's budget for chemical and biological warfare?

Dr. ROTHENBERG. I cannot answer that question.

Mr. REUSS. Dr. Emerson?

Give me the totals in the fiscal years 1967, 1968, and 1969 budgets, including expenditures at Edgewood Arsenal, Fort Detrick, Dugway, and the other bases for herbicides, nerve gases, biological warfare, whatever it comes to.

These must be at the tip of your tongue. Just give them in rounded figures, Doctor.

Dr. EMERSON. No, they are not, sir.

I'm sorry, I thought I had that information with me.

Mr. REUSS. Call the man at the Pentagon who has it and get him up here as fast as he can come, and let's have that information. Tell him to accompany himself with some responsible officials who can answer these questions.

What is the military theory behind our system of developing nerve gases, plagues, biological warfare, and so on? How are we supposed to use this in the event of war? As I understand it we pledged ourselves not to use it first and somebody else will have to use it first; is that correct?

Dr. EMERSON. That's correct.

Mr. REUSS. Well, let's look at our adversaries. The Soviet Union is one of them. If they use chemical or biological warfare on us, why don't we retaliate—in the same way we would retaliate in the event of a nuclear attack—by the use of our Polaris submarines and other retaliatory devices? Why, in short, do we fool around with all of

these very destructive agents which so far seem to have added nothing to the security of America but seem to be poisoning our environment and to have resulted in a very considerable kill of livestock in Utah last year?

Just tell us in lay language what we are up to here. I can't understand why, because others may be up to deviltry of a not very effective nature, we should be up to it.

Dr. EMERSON. May I refer to you three documents, the first being Report No. 23 from the House of Representatives Committee on Space and Astronautics which went into this subject and presented and published their findings. One from the Senate Committee on Foreign Relations, the 86th Congress, second session. And the statement in the Congressional Record of April 21 by the Honorable Robert Sikes discussing the question you have just raised.

[Subcommittee note.—The materials referred to above by Dr. Emerson are, respectively: "Research in CBR (Chemical, Biological, and Radiological Warfare)," House Report No. 815, 86th Congress, first session, August 10, 1959, reprinted by the Department of the Army March 1960, pamphlet No. 3–2; "Chemical-Biological-Radiological (CBR) Warfare and its Disarmament Aspects," a study prepared by the Subcommittee on Disarmament of the U.S. Senate Committee on Foreign Affairs, 86th Congress, second session, August 29, 1960; and "A Discussion of the U.S. Position with Regard to Chemical and Biological Warfare," Extension of Remarks of Hon. Robert L. F. Sikes of Florida, Congressional Record, April 21, 1969, pages E3167–69.]

Mr. REUSS. Right. And now will you answer my question? You are the Acting Deputy Assistant Secretary for Research and Development. What are we up to here? What is the strategic posture? How are we going to use these plagues, biological weapons, and these nerve gases, the chemical weapons?

Let's hear your scenario.

Dr. EMERSON. I don't have a scenario.

Mr. REUSS. Well, you had better get one. You seem to be in charge of this stuff.

Dr. EMERSON. I'm not in charge of it.

Mr. REUSS. Well, let's have someone from the armed services answer. General Stone, Dr. Rothenberg, you all seem to be running away from it. Can't anybody suggest why we are spending, I'm told, hundreds of millions of dollars every year for bacteriological and chemical warfare?

Well, if any of your associates at the Pentagon have any thoughts later on we will leave some space in the record at this point for you to tell the public what your program is all about.

Dr. EMERSON. Let me quote the figures Representative Sikes gave which I am sure were obtained from the Defense Department.

Mr. REUSS. On the budget?

Dr. EMERSON. Yes.

Mr. REUSS. No, we can hear from our committees at any time. I want the Pentagon, you people, to tell me what the chemical and bacteriological warfare budget is. And as I understand it you have got somebody on the way up here right now to tell us that. Is that correct?

Dr. EMERSON. I have asked someone to get the information for me. I'm sorry, I had it laid out to bring and it was an oversight.

Mr. REUSS. But have whoever is close to your desk pick that up, get into one of those limousines and come on over and tell us. Is that what is being done?

Dr. EMERSON. Not quite.

Mr. REUSS. Why not?

Dr. EMERSON. We don't have a limousine.

Mr. REUSS. Well, how is this person getting over here?

Dr. EMERSON. The information will be phoned over and I will give it to the committee.

Mr. REUSS. All right.

(Subsequently the following data were received from the Department of the Army:)

DEPARTMENT OF DEFENSE CHEMICAL AND BIOLOGICAL ACTIVITIES—DATA PROVIDED TO CHAIRMAN REUSS, SUBCOMMITTEE ON CONSERVATION AND NATURAL RESOURCES, HOUSE COMMITTEE ON GOVERNMENT OPERATIONS, RE DEPARTMENT OF DEFENSE BUDGET FOR CHEMICAL AND BIOLOGICAL ACTIVITIES

[In millions]

	Fiscal year 1967 (Prog.)	Fiscal year 1968 (Prog.)	Fiscal year 1969 (budget) [1]
Procurement:			
Army	35.3	178.9	156.0
Navy	16.3	4.9	11.8
Air Force	95.7	64.3	73.5
Total	147.3	[2] 248.1	241.3
Research, development, test, and evaluation:			
Army	87.3	79.2	82.6
Navy	1.5	3.3	3.6
Air Force	12.1	4.7	4.1
Total	100.9	[2] 87.2	90.3
O. & M. A	([3])	([3])	20.0
Total	248.2	[2] 335.3	351.6

	Fiscal year 1967	Fiscal year 1968	Fiscal year 1969 [1]
Procurement:			
Lethal Cml	8.7	3.2	----------
Smoke, flame, and incendiary	70.9	122.0	138.1
Riot control	17.3	66.3	80.5
Herbicides	39.5	31.4	5.2
Defense equipment and miscellaneous	10.9	25.2	17.5
Total	147.3	248.1	241.3
Research, development, test, and evaluation:			
General basic			9.0
Offensive	50.8	43.6	31.0
Defensive	27.3	25.1	30.3
Test and evaluation	22.8	18.5	20.0
Total	100.9	87.2	90.3

[1] Furnished to Chairman Reuss at hearing on May 21, 1969, by Dr. K. C. Emerson, OASA (Research and development).
[2] Previously furnished Congressman McCarthy.
[3] Not available.

Mr. REUSS. And also at this point in the record if you have a justification for the chemical and bacteriological warfare effort, please insert it at this point in the record.

(Subsequently, the following statement was received from the Department of the Army:)

It is the objective of the United States to develop and maintain a defensive chemical-biological (CB) capability so that U.S. military forces could operate for some period of time in a toxic environment if necessary; to develop and maintain a limited offensive capability in order to deter all use of CB weapons by the threat of retaliation in kind; and to continue a program of research and development in this area to minimize the possibility of technological surprise. This policy on CB weapons is part of a broader strategy designed to provide the United States with several options for response against various forms of attack. Should their employment ever be necessary, the President would have to authorize their use. The United States does not have a policy that requires a single and invariable response to any particular threat. In the field of CB wafare, deterrence is the primary objective of the United States.

As a matter of policy, the United States will not be the first to use lethal chemical or biological weapons, but we are aware of the capabilities these weapons place in the hands of potential adversaries. For this reason, it is important to carry on our R.&D. program in CB, not only to provide necessary equipment, such as detection and warning divices, but to define and quantify more fully the potential threat to our country from these weapons, and the hazards involved if they are ever used against the United States.

It should be emphasized that CB is not just one system but many systems, all with different effects and different uses. Some chemical weapons are designed to kill, others are designed to incapacitate. Other chemical systems include riot control agents, herbicides, smoke and flame. The United States does not consider these latter systems as weapons to fall within the purview of the Geneva Protocol of 1925.

Mr. REUSS. There was testimony yesterday concerning Venezuelan equine encephalitis, an example of a biological warfare agent.

Dr. Rothenberg, what is the mortality record of that virus, VEE, I think it's called.

Dr. ROTHENBERG. Large epidemics in North and South America run to something on the order of six-tenths of 1 percent.

Mr. REUSS. Six-tenths of 1 percent of the people who——

Dr. ROTHENBERG. Who became infected.

Mr. REUSS. Who become infected die.

What about incapacity?

Dr. ROTHENBERG. The incapacity is of very short duration. The percentage of the populace which would become incapacitated depends upon the dose which they receive. The normal mode of transmission is the mosquito. It's the way it is carried in South America areas generally.

Mr. REUSS. Is there VEE at Dugway now?

Dr. ROTHENBERG. There are evidences of VEE in Florida, Louisiana, in Utah, and I think essentially wherever you have an area that is on an international bird flyway you should be able to find evidences of Venezuelan if one would take the trouble to look for it.

I think this was pointed out in the paper of Dr. Gebhardt.

Mr. REUSS. Is there in the stockpile of biological warfare materials at Dugway, Utah, at the present time, VEE?

Dr. EMERSON. Information on what is in the stockpile is security information which will be provided in the executive session if you so desire.

Mr. REUSS. Right.

Mr. Clerk, will you clear the hearing room, please, and dismiss all persons without top secret clearance?

(The hearing room was cleared.)

(Discussion off the record.)

Mr. REUSS. Mr. Vander Jagt.

Mr. VANDER JAGT. Thank you very much, Mr. Chairman.

I thank all three of you for being here this morning and I think it is only fair to share with you an impression I have gained from an examination of this case.

There seems to be a confusion—and I hope perhaps you can clear up this impression and I would like to give you an opportunity to do so. But the impression that I have is one of a series of events and facts that are confusing, to say the very least. There appear to be a great number of conflicts, and there almost appears to be a pattern of deception. And what I'm concerned about it whether that pattern of deception was deliberate, or whether erroneous information was given from which people could reach false conclusions. But I thought it only fair to share with you my impression.

What I'm interested in is getting, as completely as possible for the record, the facts in this case.

My first area of concern is with the VX nerve gas that was tested on March 13. Sheep began to become ill and die, and it was not until March 22 that the Army publicity revealed that VX nerve gas had been tested on March 13; that Dr. Osguthorpe, when he first arrived on the scene, suspected that it was an agent of this kind; and that what made it more difficult for these investigating teams—at least as it seems to me—to confirm their diagnosis was the total lack of information that any nerve gas had been tested in recent days or in recent weeks.

I also get the impression that what you have been telling us is that a rancher called immediately and said, "Has there been any biological testing?" and the answer was "No", and that was a truthful and accurate answer. But it also seems difficult to me that investigating teams can be milling around and that sheep can be dropping dead like flies and that no one can pin down the fact until a period of 9 days that there had in fact been nerve gas testing.

I would like to call to your attention—and perhaps these facts are erroneous—that Dr. J. E. Rasmussen, veterinarian in charge of the Department of Agriculture's Animal Health Division told the Salt Lake Tribune on March 20 that the sheep did not have a contagious disease but were experiencing the effects of "some sort of poison," and insecticides or a poison plant were suggested as possible causes.

As for a chemical weapon from Dugway, the same news story quoted the Dugway information officer: "When we first found out about it we checked and found we had not been running any tests that could cause this."

Now to your knowledge was any statement of that nature made by an information officer at Dugway?

Dr. EMERSON. General Stone made the investigation.

General STONE. Sir, I didn't arrive out there until late on the day of the 22d. I inquired as to the same thing. The replies that I got from the information officer and from the post commander at that time were that they had interpreted their own questions that they were getting from the outside and the very little bit that they had seen of what was happening in Skull Valley as to being either due to poison plants, perhaps insecticides, or perhaps to some viral infection.

Throughout that whole area there are from time to time small epidemics among the sheep of a variety of sorts, either due to true diseases

or from eating poisonous plants. That question was apparently answered in a broad way and by their thinking in terms of viral infections which might have been caused from the Dugway Proving Ground and as has been said, there had been no tests of that sort for a considerable period.

As it turned out later and after I got into the investigation and began to see that probably there was some chemical poison of some sort, either from our testing, from insecticides or from poison plants that they were eating and from the 22d on, the circumstantial evidence mounted very rapidly and it appeared that we certainly were involved in this.

I so stated to the Utah delegation on the 25th back here in Washington.

Mr. VANDER JAGT. On the 25th?

General STONE. Yes, sir.

Mr. VANDER JAGT. But to your knowledge, this is an accurate statement then, that on the 20th a veterinarian from the Utah State Department of Agriculture was suspecting some sort of chemical poisoning and an information officer at Dugway said, "Well, when we heard about that suspicion we made some checks and we had not done any testing of anything that could cause anything like this"?

General STONE. Sir, I read these same statements in the press. Apparently all the communication, as far as I could find out, was by telephone and that I believe is probably an accurate statement of what transpired.

Mr. VANDER JAGT. That, you believe, was an accurate statement?

General STONE. Yes.

Mr. VANDER JAGT. Let me read you further sort of a review of the events that was given in the testimony of Dr. Osguthorpe when he appeared before our committee yesterday.

He pointed out that he arrived on March 19 on the scene. He had been in California. And his immediate diagnosis that leaped out at him after seeing the lack of lesions and so forth was that this was some form of chemical poisoning. And then he described the tests that he ran in the laboratory, and the breaking down of some agents that would indicate again a chemical poisoning.

And then on March 20 he went back and further confirmed this diagnosis, and on March 22 there was a meeting then with the Utah State Department of Agriculture and the Governor of Utah. So it was then suggested that it was some form of poisoning as the result of chemical testing. And he told us yesterday:

"The Army denied using any organic phosphate compounds since last July of 1967."

And then he goes on:

"The Army—" being the prime suspect on the basis of his diagnosis, "—was invited to meet with the Governor on March 22, 1968."

And he says: "Prior to this meeting they emphatically denied any use of organic phosphate compounds just prior to the onset of the conditions in the sheep."

General STONE. Sir, I found no evidence that any flat statement had ever been made of that sort by Dr. Rothenberg or anyone else, denying the use of any organic phosphate.

Mr. VANDER JAGT. Well, in light of what you agreed could well be an accurate statement of the public information officer on the 20th,

would it not be possible that Dugway and some officers there had emphatically denied the use of any organic phosphate compound in its testing since June of 1967?

General STONE. I don't know, sir, other than when I arrived at the scene the interpretation of the bulk of the people there was that it had been either some naturally occurring disease or it was poison plants. The bulk of the people at the installation believed at that point in time that this was still the case.

Mr. VANDER JAGT. Had any investigating teams been informed prior to March 22 that there had been chemical testing on March 13—any kind of chemical testing?

General STONE. I don't know, sir. I cannot answer that.

Dr. ROTHENBERG. There were no investigating teams. The only investigations then going on were by the proving ground. We called in the State Health Department.

Actually the U.S. Public Health Service people started to arrive something like on the 23d. The first team of investigators arrived on the 23d, as I recall.

Mr. VANDER JAGT. I think that's one of the problems in the using of words that we have in getting down to the facts. There was perhaps no investigating team, but had not the Governor himself investigated this area? Was he not interested in what the cause was? Had not the Utah Department of Agriculture been interested and on the site prior to this time? Were there not responsible State officials investigating?

Dr. ROTHENBERG. Yes, the Governor and Mr. Waldron, the commissioner for livestock of the Utah State Department of Agriculture, did visit the area on the 20th I believe.

Mr. VANDER JAGT. And had any of these responsible officials investigating why the sheep were dying been informed by the Army prior to March 22 that there had been chemical testing on March 13, to your knowledge?

Dr. ROTHENBERG. Not to my knowledge.

Mr. VANDER JAGT. And would not that information have been very important in terms of trying to arrive at a diagnosis, as it subsequently proved that it was?

Dr. ROTHENBERG. Yes, sir.

Mr. VANDER JAGT. It was important and it would have been then?

Dr. ROTHENBERG. Yes.

Mr. VANDER JAGT. And I think you testified, Dr. Rothenberg, that many of these sheep that died or some of the sheep that died, for which the taxpayers paid more than $500,000, could have been saved had the diagnosis been confirmed earlier.

Dr. ROTHENBERG. Had we been informed of the situation at a date earlier than March 17, 1968, yes.

Mr. VANDER JAGT. It was kind of hard for them to inform you that there had been chemical testing on the 13th, however.

Dr. ROTHENBERG. I might state at this particular moment that the symptoms displayed by the sheep in the valley were not typical symptoms of VX poisoning. I think there are several such statements in the record.

It was very difficult to diagnose. There was some suspicion there was

a viral infection of the herd. Had we been informed early enough, I think it would have helped.

In fact, we were not informed until——

Mr. VANDER JAGT. In fact, this was a pretty good opportunity to put into effect the precautionary programs that you talk about, using them when something goes wrong; wasn't it?

Dr. ROTHENBERG. It just so happened there was one gigantic snowstorm on Saturday and Sunday—I don't think the sheepherders nor the ranchers got out to see the sheep until quite late on Sunday—Sunday morning some time, at which time they observed the large number that had been infected.

Mr. VANDER JAGT. If the record showed that the ranchers observed sheep as early as the 14th seriously affected and having begun to die, and took steps, you wouldn't dispute that, would you?

Dr. ROTHENBERG. That's correct. We feel if we had been informed early enough the symptoms would have been more characteristic of a nerve agent poison and it would have been more readily diagnosed. But some 4 or 5 days later it is almost impossible.

Mr. VANDER JAGT. It is certainly more difficult to make that diagnosis when you have been told there were no significant tests going on in the area. That makes the diagnosis a little harder, doesn't it?

Dr. ROTHENBERG. That's right.

Mr. VANDER JAGT. All right. Let's go to some of these other statements.

A Lieutenant Colonel Black was quoted as saying, "No other form of animal life has evidenced any symptoms whatsoever although they are located in the same area where the sheep are dying: horses, cows, dogs, birds, and rabbits."

Do you know whether or not that statement was in fact made?

General STONE. Sir, I don't know whether or not Colonel Black made the statement. I made statements very close to that subsequently when I came back here on March 25. This appeared to be the case; that is, in terms of outward symptoms and signs.

About that same period of time we began to pick up some signs in the blood of some of these other animals that they had in fact also been exposed to an organophosphate, but it is true that there were, to the best of my knowledge, no outward symptoms visible on any animals other than sheep.

Mr. VANDER JAGT. Is Colonel Black stationed there at Dugway?

General STONE. He was, sir.

Mr. VANDER JAGT. At the time all of this was taking place?

Dr. ROTHENBERG. He was the executive officer.

Mr. VANDER JAGT. All right.

Did you know that, prior to the time that Colonel Black made this statement, he had specific evidence of at least nine or 10 birds that had died on one rancher's property and Dugway had been presented with a rabbit that was showing the identical symptoms of the sheep, and that this evidence was before him prior to the making of that statement?

General STONE. No, sir; I don't. I do know that as soon as I got out there we began to look for these other animals and I began to ask that they bring them in, including Mr. Hatch and the other ranchers. The only instances of animals that I knew were being brought in were all

dead. In general they were quite dessicated, dried out. There was no blood left on which they could run tests.

I never knew of any positive signs being found in any dead animals to indicate that this was in fact what they died from.

Mr. VANDER JAGT. If Dugway had been informed that rabbits and birds had died on one rancher's property and then the rabbit had been brought in showing the same symptoms as the sheep and then Colonel Black made the statement that no other form of animal life has evidenced any symptoms whatsoever—whether it be birds or a rabbit. Would that disturb you greatly, if those facts were correct?

General STONE. Yes, sir; it certainly would.

There are, of course, in nature, animals dying all the time. These animals do have a natural life cycle and they do die, in general on the range. We believe the bulk of the animals we found, without any exception that I know of, were animals that died naturally.

Mr. VANDER JAGT. Is it common for a rabbit to gradually lose control of its muscles and go into gyrations and jerks and then lose control of every other organ that he has in his body?

General STONE. Not to my knowledge. I know very little about rabbits, but I would suspect that something was wrong if I saw such a rabbit.

Mr. VANDER JAGT. And if the people at Dugway saw that prior to the issuance of that statement, would it not be fair to assume that they would have enough commonsense to assume that something was wrong?

General STONE. Yes, sir. And that animal would obviously be alive and we should be able to get some blood from it and run a test on it.

Mr. VANDER JAGT. Now, getting to this matter of trying to get down to what in the world it was that killed the sheep, this mystery and the fact that the Army didn't publicly announce or admit that chemical testing had been done on March 13, that any significant testing had been done since June of 1967, when an investigating team did begin work: Did you display a film of the running of that test made available from the Utah Department of Agriculture to an investigating team of 10 or 12 people?

General STONE. Yes, sir. I do not have the precise date. It would be somewhere around the 24th or the 23rd or the 22d of March.

Mr. VANDER JAGT. How many showings of that film to this team were there on that occasion?

General STONE. I can recall our going through it two or three times. Whether it was shown subsequently or not I do not know. This is a classified film, sir.

Mr. VANDER JAGT. How does it happen you went through it two or three times?

General STONE. Everyone was interested in what had happened precisely: Was the airplane actually well located? Did they have the airplane in the camera frame completely?

Mr. VANDER JAGT. Let me ask you this and ask you to comment on it. Is it possible that one of the reasons it was shown more than once is that 10 or 12 people saw the film and there were three cameras which filmed the running of this test and that in the formal presentation the investigating team saw a film of relatively short duration that was

taken from one camera; and then the investigating team left the showing room, and one of the members of the investigating team, because he was a pilot, concluded that there must have been more film than was shown and asked permission to go back and see if he could see the rest of the film—that that was done and the impressions that were gathered from the two showings were drastically different? Is that possible?

General STONE. Sir, it is; and I think I recall the incident. I believe this was Dr. Osguthorpe and I believe he asked me if there was any other film and we certainly did have other cameras on it, I believe three is probably the right number. There was certainly no intent to withhold this information from him or anyone else. Dr. Osguthorpe is a pilot.

Mr. VANDER JAGT. Is it quite possible that one viewing those two showings would draw a totally different impression as to the seriousness of that malfunction, from the first film as compared to the second film which the others were not shown and was not voluntarily shown to Dr. Osguthorpe?

General STONE. Sir, not to the best of my recollection.

Mr. VANDER JAGT. If there were a malfunction and there was a camera from the side—the plane was going just about the speed of sound, wasn't it?

General STONE. It was subsonic. I have forgotten the exact speed. It was a high performance aircraft.

Mr. VANDER JAGT. With one camera to the side, as you went by and you saw the film for a few seconds, would that be as likely to reveal the amount of gas that escaped as a camera that was taken from behind that plane where you could see it on its entire course?

General STONE. It certainly would. You are right, sir. As I recall, all three cameras, or whatever the right number was, and there may well have been more than three, held the plane in sight throughout its entire wet run.

Mr. VANDER JAGT. Did the Army, prior to the showing of this film, and prior to the showing of the unabridged version, make the statement that they could account for all but 20 pounds of the VX that had been in the plane?

General STONE. Sir, these were the best calculations that were available to me at that time and this is true. But that calculation, sir, was based on all of the films that were available and not the film for any particular camera.

Mr. VANDER JAGT. Does the Army still feel that it can account for all but 20 pounds of the material?

General STONE. Sir, I have been disassociated with this for about a year and I am sure the calculations have gone further than that. All I know is that was the best estimate at that point in time.

Mr. VANDER JAGT. But you are sure that the calculations have gone somewhat farther than that?

General STONE. Yes, sir; I am sure they have been refined. Whether this is upward or downward I am not clear.

Mr. VANDER JAGT. Now, Dr. Osguthorpe was quite sure of his initial diagnosis as to what caused this. He issued a press release and this press release was carried on the AP and the UPI wires. The Associated Press quoted Dr. Osguthorpe as saying, "We are as positive as medical science can ever be that the Army tests caused the deaths.

We are very lucky that no people were killed, and as far as we are concerned the cases are closed."

That statement was going out on the wires while Dr. Osguthorpe was flying to Dugway. Did the Army do anything about that particular press release that Dr. Osguthorpe had put out?

General STONE. Sir, I talked to him on his arrival at Dugway Proving Ground.

Mr. VANDER JAGT. And would you tell us the nature of that conversation?

General STONE. Sir, I told him that from my point of view it had not been proven conclusively, and that there was certainly considerable circumstantial evidence that indicated that an Army test had been involved. As I recall, we had this calculation of the order of 20 pounds available to us at that point in time.

Mr. VANDER JAGT. Which has now been further expanded?

General STONE. I do not know what the current figure is, sir.

Mr. VANDER JAGT. But we know it is more?

General STONE. Assuming that, sir—I think that it is probably still the case that there was never at any time a question of humans having been endangered. These sheep were apparently hypersensitive as Dr. Rothenberg has pointed out, due to some reason that I have never heard the answer to. With the amounts of material that were present and apparently could have gotten off the proving ground, I still believe this is a true statement, that human beings as such were never endangered.

Mr. VANDER JAGT. Those were your views?

General STONE. Yes, sir.

Mr. VANDER JAGT. What did you ask Dr. Osguthorpe to do about his views?

General STONE. I told him, sir, that I thought that he was unnecessarily raising anxiety in the minds of the people and that it was not clear that there was in fact a true problem as far as the human population was concerned.

Mr. VANDER JAGT. Did you ask him to do anything?

General STONE. I don't recall that I did, sir.

Mr. VANDER JAGT. Did someone from the Army at that time ask him to do something?

General STONE. That could well have been. There were a number of us involved in this discussion, and from agencies other than the Army.

Mr. VANDER JAGT. Let me read you another press release, and I want to ask you whether or not the Army typed that press release and had Dr. Osguthorpe issue it. I call your attention to the first press release of a few hours earlier that Dr. Osguthorpe put out when he said, "We are as positive as medical science can be that the Army tests caused the deaths. We are very lucky that no people were killed." Now, this is the press release and I ask you whether or not the Army prepared it, and typed this press release a few hours later and gave it to Dr. Osguthorpe:

From tests that were conducted by the Utah State Department of Agriculture we are reasonably sure that these deaths were caused by an organophosphate compound. We were advised by the Army that tests with compounds of this nature were conducted on March 13, 1968, at Dugway Proving Ground. We have no evidence that there is or was ever any danger to the people in Skull Valley.

We are very fortunate in this. Final determinations have not yet been made. I am cooperating with the investigators at Dugway to see if our findings can be confirmed.

And I ask you whether or not the Army prepared and typed that second press release?

General STONE. Sir, I do not know whether we prepared it or not. It certainly sounds like the words that I just used to him then and I used just now, and I personally still believe. I am sure it was typed at the post. He was on the post at the time this was done, and we certainly had the only typewriters available, and it was probably one of our employees that typed it. I believe he wrote it based on my discussions and the discussions of others with him, but I believe those were his words.

Mr. VANDER JAGT. Your testimony is that it was prepared in consultation with the Army?

General STONE. Sir, I frankly don't recall whether he wrote this in my presence or subsequently.

Mr. VANDER JAGT. I ask you if that second press release squares with this, and this was the statement included on the "First Tuesday" NBC television program where Dr. Osguthorpe was quoted as saying this:

And that's the whole end of the incident. This could have been very, very easily washed into one of our reservoirs or drinking water, had it been rained out over one of these areas. We might have had some disastrous results. One specifically, the Deer Creek Reservoir, could very easily have gotten that far had it not been rained out. I am sure that had this got into a water supply, why it would have definitely killed people. You cannot conduct this type of experiment without endangering the life around you.

I ask you whether or not that statement by Dr. Osguthorpe sounds like the same man who was speaking in the second press release that was prepared in consultation with the Army?

General STONE. Sir, it is certainly hard to reconcile the two. There is no question about it.

Mr. VANDER JAGT. Thank you very much.

Now there's a Dr. Gubler or something to that effect—I think it is G-u-b-l-e-r, a doctor in a hospital in Tooele, and he has been quoted in the press as saying that he has treated workers at Dugway for gas poisoning. Do you know anything about that?

General STONE. Sir, in the Tooele Hospital Dr. Gubler is employed. I have never met him. Whether he is the senior surgeon there or not I am not clear.

As in any work with toxic materials—and this is true in normal chemical plants; it's true in hospitals; it's true anywhere where they work or there are chances of exposure of individuals to these toxic materials. All employees, in the case of the Army at Dugway Proving Ground and in the case of normal hospitals, if they come up with any peculiar symptoms—and they are told what the symptoms are for the materials they are working with—they are advised very strongly, and directed, in fact, to contact the surgeon and the medical personnel on the installation who understand what is happening and what the appropriate treatment is.

This was certainly the case with these individuals, too. If these people had in fact been exposed to toxic materials—and over a period of time there have been some who had been exposed to these materials—they should have reported to the medical personnel on the post.

Mr. VANDER JAGT. Would you know about two utility pole workers who were working on Highway 40 and who were treated at Tooele Hospital for poisoning by a chemical substance?

General STONE. Sir, I know of no instance in the past where any toxic materials ever reached Highway 40.

Mr. VANDER JAGT. But if that were in fact the case, would you be disturbed by it?

General STONE. I certainly would, sir.

Mr. VANDER JAGT. Thank you.

Now was Dr. Osguthorpe advised initially by the Army that 4 days after the test you could put the sheep back in this area and that there would be absolutely no damage to the sheep?

General STONE. I don't recall this, sir. I don't recall the question coming up.

I do know that we realized, if this was our material, that there was a problem of persistence and as it turned out later, there was some persistence, as has been included in the prepared statement, sir.

Mr. VANDER JAGT. As a matter of fact, sheep put in 3 or 4 weeks later suffered damage, didn't they? June 10 they were put in.

(Dr. Rothenberg shakes head negatively.)

Mr. VANDER JAGT. No damage to sheep put in June 10?

Dr. ROTHENBERG. May I answer that?

The animals that were affected were put in at an earlier date—if I can check this, the sentinel animals that were put in in March and April were affected. I think what you are probably referring to is some forced feeding experiments which were performed at the Agricultural Research Service Station in the Department of Agriculture, with grass which seemed to have collected some of the material, where the cheat grass was force-fed to animals; the grass which had been collected on the 1st of April did produce some physiological symptoms in the animals.

There was one fatality among the test sheep that were employed. However, with grass collected on the 12th of June, 1968, using the same type of technique, force-feeding experiments by the Department of Agriculture, there was no significant decrease in blood cholinesterase levels and there were no physiological symptoms evident.

And we have this report here dated July 9, signed by Dr. Van Kampen to Dr. Paul DeLay, U.S. Department of Agriculture, which states such.

Mr. VANDER JAGT. What's the date?

Dr. ROTHENBERG. July 9.

And there is an additional report dated October 17, signed by Dr. Van Kampen to Dr. Rasmussen, stating the same. I will quote if you so desire.

Mr. VANDER JAGT. If you wish, please go ahead.

Dr. ROTHENBERG. It says:

Black sage and cheat grass were gathered at the White Rock area of Skull Valley and cheat grass at the Indian reservation on June 12, 1968.

It goes on down to the procedure for the feeding of the animals:

Erythrocytic cholinesterase activity was determined every other day.

The last sentence says:

No significant changes were noted in any of the sheep.

That's dated July 9, to Dr. DeLay, U.S. Department of Agriculture.

Mr. VANDER JAGT. I wonder always if this isn't part of the difficulty, this use of different words. Like you were asked, were you conducting any biological tests that could kill sheep, and replied, "No, we weren't"—because it was chemical. And the use of the word "team." No, there was no investigating team, even though the Governor had been there, and the Department of Agriculture people had been there.

Because did not Dr. Van Kampen find in examining those sheep that a mild cholinesterase depression was induced by the black sage that was collected on June 10, 1968?

Dr. ROTHENBERG. I'm quoting from his letter, sir.

Mr. VANDER JAGT. I'm quoting from his testimony yesterday.

Dr. ROTHENBERG. I beg your pardon.

(Subsequently, Dr. Van Kampen submitted the following statement relating to the above matter:)

In reference to an apparent conflict in testimony given to the Conservation and Natural Resources Subcommittee may I submit the following: Animals fed forage collected in June 1968 did not show clinical signs of organophosphate poisoning. In a report submitted to the Agricultural Research Service and also in a subsequent publication, I stated that in addition to the absence of clinical signs, cholinesterase levels in the blood were not significantly depressed. In reviewing the data obtained from the sheep fed forage in June, I discovered that cholinesterase levels were mildly depressed in those animals that were fed black sage. On the 8th and 10th day of the feeding trial, the cholinesterase level in one sheep fed black sage was measured at 0.09 (delta pH method). This is somewhat lower than the normal range of 0.15 to 0.25, but not low enough to induce clinical signs. This additional information had not been made officially available to the U.S. Army or the Dugway Proving Ground prior to the committee hearing in Washington, May 20, 1969.

Mr. VANDER JAGT. Incidentally, when you were originally testing some sheep after this, did you not point out to some of the investigating team that though the sheep were sick they weren't having the same symptoms as the sheep that had died in the aftermath of the March 13 testing? Is that correct?

Dr. ROTHENBERG. That's correct.

Mr. VANDER JAGT. And then was it pointed out to you, yes, but there were completely different sheep, these were sheep from Salt Lake City. They were farm sheep. And was it not then suggested to you that, "how about getting some ranch sheep from the area?" And when you did do that you found that the symptoms were approximately the same. Is that correct?

Dr. ROTHENBERG. That is correct. Animals were acquired from Deseret Livestock Co. at the north end of Skull Valley which had not been affected. The symptoms were essentially the same, when fed experimentally, except for two major things; and this is the permanent torticollis, the twisting of the neck and scoliosis, which never developed in the experimental animals and which was quite evident in field animals in Skull Valley.

Mr. VANDER JAGT. But they were approximately the same, many of the symptoms?

Dr. ROTHENBERG. Approximately.

Mr. VANDER JAGT. And much more markedly the same after you used a similar sample rather than going up to Salt Lake City for farm-fed sheep?

Dr. ROTHENBERG. This is correct. But yet the scoliosis and torticollis did not develop into a permanent nature on these range animals.

Mr. VANDER JAGT. I understand.

General Stone, how much did you pay roughly, just a ball park figure, for the sheep that died?

General STONE. Sir, I was not involved in this action. This was done at the Department of the Army level.

Dr. EMERSON. I think it was about $50 a head.

Mr. VANDER JAGT. I thought it was closer to $66. Would anyone care to dispute that?

Does anyone know how much was paid for these sheep just a little while before, when they were purchased?

Dr. ROTHENBERG. Yes; about $35 a head. Except that these animals, according to the claim put in by the rancher and verified by the U.S. Department of Agriculture, indicated that the situation was a bit different in that these were all ewes who were about to lamb within the next month or two. They were heavily laden with wool, each of which would have contributed toward the income on the sale of the animals.

The Department of Agriculture evaluated the sheep at that given price per head. It was a claim recognized by the Army.

Mr. VANDER JAGT. But if it were in fact the case that the ranchers had paid about $25 rather than $33 per sheep, and that the ranchers estimated that in the passage of the period of time they would have increased in value about $7, and that if in fact the Army paid about $66 a sheep for the dead sheep, would that not be a rather high price to pay?

Dr. ROTHENBERG. Yes; that would be a high price to pay. I think what has been done here is that one has averaged out the total value over the number of animals for which the rancher was being paid. Among the herd of animals involved were a "group of prize bucks in addition to the ewes" and these bucks come to a lot more than $30 a head. It's probably around several hundred dollars a head.

Mr. VANDER JAGT. General Stone—about two more questions, Mr. Chairman. I am sorry.

Mr. REUSS. Go right ahead.

Mr. VANDER JAGT. Certainly the Army had a great deal of difficulty in admitting—and I am not sure the Army admits yet—that their testing of VX on March 13 had anything to do with the killing of the sheep. But if it did, that would be of rather serious consequences; wouldn't it?

General STONE. I am not sure I understand the nature of the question.

Mr. VANDER JAGT. Let me be completely fair and get it all out before you before you comment on it.

You were quoted as saying that there are many confusing aspects in this case, and I certainly agree with that statement. You then said, "If we are the cause of this"—namely the killing of the sheep—"if we are the cause of this, we have a problem."

You still stand by that statement, don't you?

General STONE. Yes, sir.

Mr. VANDER JAGT. And could not the fact that there would then be a problem be one reason that the Army was very anxious to have it determined that they were not the cause for the killing of the sheep?

General STONE. Well, certainly, sir, we would like to have been absolved. I, certainly, during my period out there, looked at all possibilities, everything that anyone could think of, and it was largely by the accumulation of negative evidence that I reached the conclusion in my own mind, with the buildup of circumstantial evidence, that we were very likely involved, and this I so stated.

Mr. VANDER JAGT. Could you give me an estimate of the expense that was involved in personnel coming from Washington to Dugway when efforts appeared to show that the chemical testing on March 13 had not caused the death of the sheep?

General STONE. Sir, may I add something to what I just said? My instructions were, sir, not to absolve the Army. My written instructions from my superior, General Besson, were to arrive at the true cause and to recommend actions to him in accordance therewith and I certainly did not try to absolve the Army. But as I recall, we had on the order of 10 to 15 people from Washington—Army personnel. There were other additional people from other Federal agencies who came of the volition of their own agencies. I would venture a guess that the expense for each of those individuals was on the order of $500, covering a period of several days, so this would be on the order of say $5,000 to $10,000 for the Army personnel involved. I do not recall this number totaled up, sir.

Mr. VANDER JAGT. Just one final question.

The Army now takes the position that—well, before I get to that, under the ad hoc committee's recommendation there is a recommendation that these tests can be continued as long as you do not do so at an altitude of higher than 300 feet; is that correct?

General STONE. I believe this is correct, sir.

Mr. VANDER JAGT. This test that caused the killing of the sheep was in fact at an altitude of 150 feet, wasn't it?

General STONE. The bulk of the run was, sir. And, as you know, and as you stated earlier in the hearing, there was an apparent malfunction. The pilot pulled up while some of the agent was still dribbling out, and it apparently dribbled out up to some 1,200 to 1,400 feet.

Mr. VANDER JAGT. So that the ad hoc committee's recommendation doubles the altitude that was in fact the altitude of the test on March 13; is that correct?

General STONE. Yes, sir. Although in the past we have done tests in the range of elevation from 300 feet on down.

Mr. VANDER JAGT. Then let me ask you this final question. It is the position of the Army that there is absolutely no danger no matter what malfunctions may occur to human life in the area?

General STONE. From this particular test, sir?

Sir, I cannot attest to the Army's position.

Mr. VANDER JAGT. Give us your personal opinion.

General STONE. My personal opinion is there was none, as the test was conducted.

Mr. VANDER JAGT. Well, let me ask you this. If in fact the Army was wrong when Colonel Black issued his statement that there had not been any damage to any other animals, and if in fact there were dead birds and rabbits that had been brought to Dugway and the Army was thus wrong about animals, is it not possible at least that the Army could be wrong about human beings and the danger to human beings?

General STONE. Sir, I do not believe so. There is considerable confirming evidence. The Public Health Service did extensive surveys—both the Federal and State personnel did public health surveys of the people who live in that valley, taking blood samples, which is by far the most sensitive indication. They never found any indication of cholinesterase depression of the blood, so this indicates to a very fine precision whether there had been any exposure at all to humans. Apparently the humans never picked this material up although it was ingested by the sheep presumably from the cheat grass and bud sage.

Mr. VANDER JAGT. I merely asked you a hypothetical question. If in fact the Army was wrong about animals is it not possible that the Army could be wrong about the dangers to human beings?

General STONE. No, sir. To the best of my knowledge we are not wrong about the animals.

Mr. VANDER JAGT. But if you were, and if the records so demonstrated?

General STONE. This, sir, would be conjecture.

Mr. VANDER JAGT. One other question, and it is really for Dr. Emerson.

You told us this morning that the toxic effects of VX on human beings had been determined for both inhalation and percutaneous methods of exposure. What human beings were you testing by exposure to VX?

Dr. EMERSON. These are tests run, as any toxicological testing is done, at very low levels on volunteers.

Mr. VANDER JAGT. On volunteers?

Dr. EMERSON. Yes.

Mr. VANDER JAGT. Volunteers from the Army?

Dr. EMERSON. Yes.

Mr. VANDER JAGT. I think, Mr. Chairman, I have taken enough of the committee's time. Thank you very much.

Mr. REUSS. Mr. Gude?

Mr. GUDE. Dr. Rothenberg, as a result of this test and the death of the sheep and the circumstances surrounding it, have you learned more about this agent than you knew previously?

Dr. ROTHENBERG. Yes, definitely. For one thing we have learned a considerable amount of information with respect to sheep with which we have not concerned ourselves previously.

Mr. GUDE. Have you learned anything about the residual character of this agent?

Dr. ROTHENBERG. Yes. We have learned something about the residual character of the agent.

Mr. GUDE. Have you learned anything more about the extent to which this material could be distributed than you knew previously?

Dr. ROTHENBERG. With respect to transport, distribution over the terrain? Not very much, really. I think the kind of transport which was experienced could have been anticipated with this type of malfunction.

Mr. GUDE. Did I understand you to say earlier that never before had this material gone outside of the test area?

Dr. ROTHENBERG. That is correct.

Mr. GUDE. I don't know whether you are familiar with Dr. Osguthorpe's testimony on page 5, but he says "Other animals in the

area"—and this is the area where the sheep-kill occurred—"had depressed cholinesterase levels. Tests on the cattle and horses showed their levels to be depressed. Blood samples from sheep herds belonging to Deseret Livestock Co. to the north of the White Rock area had lowered cholinesterase levels. Rabbits and birds were affected. Rodents were also affected."

And then further down, in the paragraph following it, he said, in speaking about the testing of the sheep, "This indicated that the sheep from the area around the proving ground had possibly had previous exposure."

General STONE. Sir, two points I would like to make. First of all, Dr. Osguthorpe was with us from the time I arrived there and participated in both classified and unclassified briefings and hearings on a daily basis. He had all the data we had. I hope we had all the data that he had at that time.

Second, to the best of my recollection I have never heard of these particular tests on other animals where he got depressed cholinesterase.

The other point that was mentioned—and I am not an expert—is that animals by eating some of the vegetation out there may also get depressed cholinesterase. Some plants which are poisonous and toxic will produce depressed cholinesterase in animals when eaten in sublethal quantities. This was one of the points of confusion, and there were many.

("22 Plants Poisonous to Livestock in the Western States" (U.S. Department of Agriculture Information Bulletin No. 327, Apr. 1968), handed to subcommittee members at this point, is in the subcommittee files.)

Mr. GUDE. Mr. Chairman, you and Mr. Vander Jagt have been very adept and I think you covered this area very well, but there is one observation which I had that really disturbs me. They have a public information officer at Dugway and here the Army is testing a very lethal compound under very serious circumstances and yet everyone has such difficulty in developing rapport with the owners of the ranches and the people on the outside, and if a reporter calls and uses a term over the phone, why, it is so easily misunderstood. You know, if you don't know the language, well, don't expect to get any information. This seems to me the sort of the sum and substance of what I get, and you wonder what the duties of a public information officer are and what he is really for.

Thank you.

Dr. EMERSON. May I say something on that point?

Mr. REUSS. All right.

Dr. EMERSON. That is a point which appears on page 10 of my statement. To correct that deficiency, we now brief State officials and personally visit local ranches.

Mr. GUDE. I am happy to hear this. This testing was evidently going on for 25 years prior to the Dugway incident and I am glad to hear that there is some remedy in sight.

Mr. REUSS. Thank you, Mr. Gude. I have been puzzled, to say the least, by the Army's statement and, in an effort to clarify matters, I now recall the witness, Dr. Osguthorpe—Dr. Osguthorpe, are you in the hearing room? Will you step forward, sir?

I am going to ask you to take the oath, Dr. Osguthorpe.

(Whereupon, Dr. D. A. Osguthorpe was recalled as a witness and having been first duly sworn, was examined and testified as follows:)

FURTHER TESTIMONY OF D. A. OSGUTHORPE (D.V.M.), VETERINARIAN; CONSULTANT TO UTAH STATE DEPARTMENT OF AGRICULTURE, SALT LAKE CITY, UTAH; SPECIAL REPRESENTATIVE OF GOVERNOR OF UTAH IN INVESTIGATION OF MARCH 1968 SHEEP DEATHS

Mr. REUSS. Dr. Osguthorpe, you were present at a meeting in the Governor's office in the Utah State capital on Friday, March 22, 1968, were you not?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. At that time, the Army representatives present admitted that there had been a testing of an organophosphate agent, namely VX nerve gas on March 13, 1968. Is that not correct?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. Was that the first time that the Army had made the admission that a testing of VX had taken place on March 13?

Dr. OSGUTHORPE. Yes. To our knowledge this is the first time they admitted that there had been a test of these type of compounds prior to the sheep incident.

Mr. REUSS. State whether or not it is a fact that prior to that March 22 meeting, which was 9 days after the March 13 VX test and which we now know to have taken place on that date, you were informed by representatives of the Army on several occasions that no testing of an organophosphate had taken place?

Dr. OSGUTHORPE. That is correct.

Mr. REUSS. Were you present in the office of the commanding officer of Dugway Proving Ground, Colonel Watts, on March 20, 1968?

Dr. OSGUTHORPE. Wednesday, March 20?

Mr. REUSS. That is 2 days before the March 22 meeting in the Governor's office.

Dr. OSGUTHORPE. Yes.

Mr. REUSS. And at that time were you categorically assured by representatives of the armed services that no testing of an organophosphate had taken place during March 1968?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. Did the commanding officer, Colonel Watts, give you that categorical assurance?

Dr. OSGUTHORPE. Yes.

Mr. REUSS. Could there be any question that he was merely assuring you that the testing of a biological warfare agent had not taken place in March?

Dr. OSGUTHORPE. I don't know because we were not that specific.

Mr. REUSS. Well, what specific question did you ask concerning testing?

Dr. OSGUTHORPE. We asked if there had been any testing which could be responsible for the death of the sheep.

Mr. REUSS. You did not restrict your question about testing to biological agent testing?

Dr. OSGUTHORPE. No.

Mr. REUSS. And the representatives of the armed services did not restrict their answers to biological agents?

Dr. OSGUTHORPE. No.

Mr. REUSS. Had you been informed in timely fashion by the military that a test of VX had in fact taken place on March 13, would you by the administration of atropine or other antidotes have been able to save a substantial number of those sheep from dying?

Dr. OSGUTHORPE. I am sure that, had the information been available that there had been testing and antidotes were available that could have been given sheep the day following the March 13 test, a considerable number of these sheep could have been saved.

Mr. REUSS. You have heard the testimony that the Army proceeded to pay the owners of the sheep—I think the testimony was some $66.

Mr. VANDER JAGT. That was my statement. I think the testimony was $50.

Mr. REUSS. Do you know anything about the price those sheepowners paid for those sheep?

Dr. OSGUTHORPE. I owned part of those sheep the summer before.

Mr. REUSS. When did you sell the part of the sheep that you owned to the sheepowners?

Dr. OSGUTHORPE. I sold part of the sheep to the Anschutz Land Livestock Co. in the fall of 1967.

Mr. REUSS. How many sheep did you sell Anschutz?

Dr. OSGUTHORPE. In the neighborhood of 2,000.

Mr. REUSS. What price did they pay you for them?

Dr. OSGUTHORPE. They agreed to pay me $25.

Mr. REUSS. Per sheep?

Dr. OSGUTHORPE. Per head; and so far they have paid $20.

Mr. REUSS. And these were the sheep for which the Army then paid $66 or $50, as the case may be, per sheep a few months later?

Dr. OSGUTHORPE. That is correct.

Mr. REUSS. Do you have any personal knowledge of whether in fact the Army paid $50 or $66?

Dr. OSGUTHORPE. No, I was never consulted on the value of the sheep.

Mr. REUSS. Do you have a question, Mr. Vander Jagt?

Mr. VANDER JAGT. Yes.

Do you have, from your own personal knowledge, an estimate as to how much the Army paid per sheep, Dr. Osguthorpe?

Dr. OSGUTHORPE. I know what they paid for the sheep they got from me. At this point it is sitting at $20.

Mr. VANDER JAGT. That is the Anschutz Land Co.?

Dr. OSGUTHORPE. Anschutz Land and Livestock Co. The sheep that they purchased from me they have paid $20 for so far. They are supposed to pay $25. And the other sheep at this time would be worth in the neighborhood of between $30 and $35, because they had wintered these sheep. The only reason that they would be any more valuable than the sheep that I had was that they were on their home ranch and acclimated to their conditions; so this may add $4 or $5 to the value of them. But if you put these sheep in at $35, that would be a top figure and if we figure what it would cost to winter these sheep—if you put that up at $10 with your subsidy—you would have a top value of $45.

Mr. VANDER JAGT. A top value?

Dr. OSGUTHORPE. A top value on their sheep. And on the sheep of mine that they had, you would have a top value of $30 for the nearly 2,000 sheep that they bought from me.

Mr. VANDER JAGT. And you don't know what they paid for those sheep?

Dr. OSGUTHORPE. No. These sheep were purchased with the ranch.

Mr. VANDER JAGT. Do you know whether or not they had any information relative to dead birds or a rabbit exposed to the nerve gas before Colonel Black made the statement about their having been any animals that have shown any symptoms whatsoever?

Dr. OSGUTHORPE. Yes.

Mr. VANDER JAGT. Did they know about the birds and the rabbit?

Dr. OSGUTHORPE. I had personally delivered a rabbit to them.

Mr. VANDER JAGT. You personally had?

Dr. OSGUTHORPE. I had personally delivered the rabbit to the Dugway Proving Ground.

Mr. VANDER JAGT. Was the rabbit alive or dead?

Dr. OSGUTHORPE. The rabbit was alive.

Mr. VANDER JAGT. You testified yesterday, that in your opinion, agents of the chemical testing had been found outside the proving ground area. On what do you base that opinion?

Dr. OSGUTHORPE. On some of the investigation work, where we found the fact that some of the BIS that was used in simulated runs was present outside.

Mr. VANDER JAGT. Thank you.

I read a statement that you had made, Dr. Osguthorpe, that in your opinion if there were severe malfunction that there was danger to human life. Is that still your opinion?

Dr. OSGUTHORPE. I am still of the opinion that anything that is toxic enough to kill this many sheep would certainly kill people.

Mr. VANDER JAGT. Anything toxic enough to kill this many sheep would still and could still kill people.

One final question, and I thank you very much, Dr. Osguthorpe, and I hesitate to ask you this question because I know in addition to being a rancher you are a professional man and I know that you respect very highly the competence of the people in the Army that you have dealt with; but let me just ask you this final question. In your opinion, as you were trying to determine what was the cause of the killing of these sheep, was the U.S. Army candid and open with you?

Dr. OSGUTHORPE. Yes; they were candid and open with me.

I will qualify that. After March 22.

Mr. VANDER JAGT. How about before March 22, before, for example, some of these people arrived on the scene?

Dr. OSGUTHORPE. No information.

Mr. VANDER JAGT. No information from the Army?

Dr. OSGUTHORPE. No information.

Mr. VANDER JAGT. Were they helpful to you?

Dr. OSGUTHORPE. We had no information from them.

Mr. VANDER JAGT. Did you receive information that led others to erroneous conclusions?

Dr. OSGUTHORPE. Prior to March 22, 1968, we were led to believe that there had been no testing of this agent prior to the sheep incident.

Mr. VANDER JAGT. And so the information you received was less than candid and less than honest prior to March 22?

Dr. OSGUTHORPE. Well, any information that we received up to March 22 certainly did not aid in the diagnosis of the sheep.

Mr. VANDER JAGT. It did not aid in the diagnosis.

Thank you very much.

Thank you, Mr. Chairman.

Mr. REUSS. Mr. Gude?

Mr. GUDE. In your statement you say rabbits and birds were affected, and you also just recounted that you delivered a live rabbit to Dugway. Did you run any blood tests on these animals?

Dr. OSGUTHORPE. No.

Mr. GUDE. Thank you, Mr. Chairman.

Mr. REUSS. Thank you, Dr. Osguthorpe.

We have a call over in the House.

I understand from the testimony that the Army paid over half a million dollars in compensation for sheep, under circumstances where there has been sworn testimony that Army representatives withheld the truth on their conduct of a VX test on March 13 until such a time as veterinary medicine could not have been able to save the sheep.

I understand, too, that sheep that sold a few months before for $20 or $25 per head, and whose value has been estimated at $30 per head at the time of their death, were in fact the subject of an Army payment on which we have had testimony that it ranged between $50 and $66 per sheep. Accordingly, I instruct counsel to take up with the Department of Justice and with the General Accounting Office whether there may not have been a violation of the law by Government officials in this case and if there has been, whether appropriate procedures can be initiated to recover all or part of the half billion dollars for the taxpayers.

On the broader question of the justification or lack of justification for chemical and biological weapons, this subcommittee has no legislative concern. What we are concerned with is the pollution of the environment and, accordingly, I herewith instruct you three gentlemen and all other affected officials of the armed services to report in writing to this subcommittee, using whatever security classifications the circumstances indicate, any tests in the atmosphere as opposed to controlled inside laboratory tests of lethal chemical and bacteriological agents, within 24 hours of those tests.

Is there any reason why you can't provide that, starting at once?

Dr. EMERSON. No reason. I think I have already provided this to the counsel for the period between March 13, 1968, to the present.

Mr. RUESS. Yes. And on a continuing basis then you will see that we are currently informed?

Dr. EMERSON. Yes.

Mr. REUSS. Not just with respect to Dugway, but also at any other location.

(SUBCOMMITTEE NOTE.—Subsequently, in a letter signed by all members of the subcommittee, the Army was asked to declassify open-air testing data it had submitted in response to the above request. The subcommittee's letter, the information declassified by the Army, and a subcommittee press release relating thereto, follow:)

U.S. HOUSE OF REPRESENTATIVES,
CONSERVATION AND NATURAL RESOURCES SUBCOMMITTEE,
COMMITTEE ON GOVERNMENT OPERATIONS,
Washington, D.C., June 9, 1969.

Hon. STANLEY R. RESOR,
Secretary of the Army,
Department of the Army, Washington, D.C.

DEAR MR. SECRETARY: In accordance with this subcommittee's request, your Department has furnished to us two lists of open-air tests of lethal chemical. compounds.

One list, furnished on May 2, shows the items, agents, agent amounts, and number of items tested at Dugway Proving Ground during the period March 1968 to May 1969. The list was classified "Confidential," although a memorandum by your Department states the classification applies only to the agents and agent quantities. When Dr. K. C. Emerson testified in open hearings before the subcommittee on May 21, 1969, he mentioned nine open-air chemical agent tests, most of which were also on the list, and he included reference to type of agent and the quantity of the agent tested.

The other list, furnished on May 23, lists open-air tests programed through June 30, 1969. This list shows the Department, test places, items, agents, agent quantities, and number of items. This list is stamped "Confidential."

It is our judgment that these lists contain no data the disclosure of which to the public would be "prejudicial to the defense interests of the Nation" within the meaning of section 1(c) of Executive Order 10501. Accordingly, we request the Department of the Army to declassify these lists immediately. If you believe that any of the data contained in either list must remain classified, please advise us of the reasons therefor at the earliest possible date.

Sincerely,

HENRY S. REUSS,
Chairman, Conservation and Natural Resources Subcommittee.
JIM WRIGHT,
FLOYD V. HICKS,
JOHN E. MOSS,
GUY VANDER JAGT,
GILBERT GUDE,
PAUL N. MCCLOSKEY, Jr.,
Subcommittee Members.

[News release from Conservation and Natural Resources Subcommittee July 11, 1969]

HOUSE CONSERVATION SUBCOMMITTEE OBTAINS ARMY AGREEMENT TO RELEASE INFORMATION ON OPEN-AIR NERVE GAS TESTING

WASHINGTON, D.C.—Congressman Henry S. Reuss, chairman of the Conservation and Natural Resources Subcommittee of the House Committee on Government Operations, today announced that in response to a subcommittee request Army Secretary Stanley R. Resor has declassified information on current open-air tests of lethal chemicals, including nerve gas.

The item-by-item lists provided to the subcommittee include data on open-air tests at Dugway Proving Ground, Utah, from March 1968 through May 1969; and at three locations—Dugway Proving Ground, Utah; Edgewood Arsenal, Md.; and Fort McClellan, Ala.—during the quarter April through June 1969. Also released is a list of open-air tests of poisons which the Army plans in the current quarter, July through September 1969, at Dugway Proving Ground, Utah, and at Edgewood Arsenal, Md. The data released today include information on nerve gases known as Tabun (GA), Sarin (GB), Soman (G), and the deadly VX, as well as mustard (HD).

Reuss noted that the Army is continuing to classify and withhold information, such as type, nature, quantity, height of release, and similar data on chemical munitions under development where the Army believes such information might enable potential enemies to devise defensive systems or techniques. "However," Reuss said, "I am gratified that the Army has recognized the public interest by revealing the general extent of open-air testing of poisonous compounds."

"This is a commendable first step toward an informed and responsible public decision on whether and how much we should permit use of our great common resource—the air—for testing poison gases. I will urge the Army to continue to let the public know in advance what its test plans are," Reuss said.

Reuss added that the Army's agreement to release this information was the result of a letter to Secretary Resor, signed on June 8, 1969, by all members of the subcommittee. The subcommittee's letter to Secretary Resor followed hearings on May 20 and 21 concerning open-air testing of lethal compounds. The subcommittee had criticized the Army's attempts to hide the fact that open-air tests of VX nerve gas had killed or injured over 6,000 sheep in valleys adjoining Dugway Proving Ground in Utah.

Members of the Conservation and Natural Resources Subcommittee in addition to chairman Reuss are Congressmen Jim Wright, Democrat, of Texas; Floyd V. Hicks, Democrat, of Washington; John E. Moss, Democrat of California; Guy Vander Jagt, Republican, of Michigan; Gilbert Gude, Republican, of Maryland; and Paul N. McCloskey, Jr., Republican, of California.

Representative William L. Dawson, Democrat, of Illinois, is Chairman of the full Committee on Government Operations.

The lists of tests as declassified by the Army are attached.

PLANNED TESTING, MARCH 1968—MAY 1969, DUGWAY PROVING GROUND, UTAH

Item	Agent	Agent amount	Quantity
M139 bomblet	GB		1 round per trial (5 trials).
E139 bomblet	GB		1 item per trial (8 trials).
105 mm. projectile	GB	1.5 lb. per round	1 round per trial (3 trials).
BLU 19/B23	GB		1 round per trial (1 trial).
M55 rocket	GB		1 round per trial (4 trials).
Spray boom (truck)	GB	2 gal. per trial	3 trials.
8 in. howitzer shell	VX	14½ lb. per round	1 round per trial (5 trials).
Spray boom (truck)	VX	2 gal. per trial	2 trials.

PLANNED TESTING, 4TH QUARTER, FISCAL YEAR 1969

DESERET TEST CENTER, UTAH (DUGWAY PROVING GROUND, UTAH)

Item	Agent	Agent quantity per item	Number of items to be tested
U.S. Army:			
8 in. shell, 50 ft. release	VX	15.4 lb	4
E139 bomblet	GB		4
Do	GB		4
M55 rocket warhead	GB		4
M23 land mine	VX		6
Test fixture, ground release [1]	VX	10 lb	3
Do [1]	HD	do	3
155 mm. shell, ground release [1]	GD	12.5 lb	10
Test fixture, ground release [1]	GA	1.2 lb	16
U.S. Navy:			
Bomblet	G-type	3 lb	6
Defense system challenge, ground release [1]	GB or VX	do	3
U.S. Air Force: BLU-19 bomblet	GB		4

EDGEWOOD ARSENAL, MD. (ALL ARMY)

155 mm. shell, ground release [1]	VX	6.5 lb	[2] 8
Test fixture	EA 1356	100 g	[2] 24
Do	GB	50 g	[2] 20
E139 bomblet (EOD test)	GB		1
M23 land mine	VX		3
E139 bomblet	GA		[2] 14
	GB		[2] 8
	GD		[2] 30
Test munition	VX	10 lb	2

Footnotes at end of table on p. 150.

FORT McCLELLAN, ALA. (CHEMICAL CORPS SCHOOL DETECTION AND DECONTAMINATION EXERCISES[3]

Bulk agent, poured on a suitable surface for detection and decontamination exercises.	HD	2 gal	1
	HD	1 gal	5
	HD	160 cc	1
	HD	120 cc	1
	HD	80 cc	6
	HD	40 cc	5
	GB	42 cc	5
	GB	40 cc	10
	VX	42 cc	5
	VX	42 cc	8

[1] Ground releases are statically detonated or functioned.
[2] To be conducted this quarter or next quarter, depending on availability of facilities.
[3] Chemical agent decontamination and detection exercises are conducted to train chemical specialists in techniques for these operations. The specialists are subsequently assigned to Army divisions and decontamination teams.

LETHAL AGENT OPEN-AIR TESTS SCHEDULED, 1ST QUARTER, FISCAL YEAR 1970

DESERET TEST CENTER, UTAH (DUGWAY PROVING GROUND)

Item	Height of release	Agent	Agent quantity per item	Quantity of item to be tested
U.S. Navy: V bomblet	Ground	VX	1 lb	3
U.S. Army				
55 gal. drum, portable water	do	GB	Less than 2 lbs	5
		HD		
		VX		
M2XR		XR		75
155 M121 projectile		GB		28
155 M121 projectile		VX		28
155 M121 projectile		GB		6
155 M121 projectile		VX		6
4.5-in. mortar	Ground	HD	6.0 lbs	148
		HT		
155	do	G	12–14 lbs	30
M23 land mine		VX		12
M56 warhead (M55 rocket)		GB		10
U.S. Air Force: Test fixture	Ground	HD	8 lbs	7

EDGEWOOD ARSENAL, MD. (ALL ARMY TESTS)

155 howitzer shell	Ground	VX	6.5 lb	7
Test fixture	do	EA 1356	100 gm	24
Do	do	EA 1356	11 lb	3
Do	do	GB	50 gm	20
E139 bomblet (EOD test)		GB		1
Test bomblet	Ground	VX	1 lb	8
M23 land mine		VX		3
155 howitzer canister	Ground	VX	3 lb	9
Test spray fixture	1 meter	GA	1.3 lb	16
		GB	do	8
		GD	do	16
		VX	10 lb	2
E139 bomblet		GB		4
		GD		8

Dr. EMERSON. May I go back to the question you mentioned earlier about the sheep thing?

Mr. REUSS. Yes.

Dr. EMERSON. The amount that was paid, $376,685——

Mr. REUSS. That was the first payment?

Dr. EMERSON. That is payment for the animals and for the damage to the range, $198,000. This figure was arrived at after consultation with the U.S. Department of Agriculture officials. I also asked Mr. Waldron, the commissioner of livestock, a personal question of whether this was a reasonable payment or not in view of his experience in the livestock values in Utah, and he said in his opinion it was.

Mr. VANDER JAGT. Mr. Chairman, if my arithmetic is correct—what was the figure that you paid, the first payment?

Dr. EMERSON. $376,685.

Mr. VANDER JAGT. And there were 6,400 sheep killed, and I make no claim to be a mathematician, but that comes close to $66 a sheep.

Dr. EMERSON. Yes.

Mr. VANDER JAGT. A rather generous payment according to the testimony of a rancher.

Dr. EMERSON. In addition there were some which were not killed but which were damaged and payment was included for those.

Mr. VANDER JAGT. The total of 6,400. So there were only about 4,000 killed; is that right?

Dr. EMERSON. Right.

Mr. VANDER JAGT. So we are talking about a really generous settlement.

Dr. EMERSON. 4,372 killed and 1,877 for which there was permanent injury.

Mr. VANDER JAGT. Which they could sell for dog food and so forth?

Dr. EMERSON. Yes.

Mr. VANDER JAGT. So they got in the neighborhood of $75 a sheep.

(Subsequently, the Department of the Army submitted the following report on the amount of its compensation for the loss of the sheep:)

Concerning the amount of payment approved by the U.S. Army as a result of a claim for $431,951.68 resulting from the death of 4,372 sheep, the following further information is furnished:

1. On June 7, 1968, the Anschutz Land & Livestock Co., Inc., submitted a claim in the amount of $390,770.81 for the loss of 6,249 sheep plus miscellaneous expenses as a result of the March 13, 1968, incident. The claim was subsequently amended to the amount of $431,951.68. In order to simplify adjudication procedures, the claimant expressly reserved the right to make a separate claim for diminished value of its land and potential loss in marketing surviving sheep and cattle.

2. On July 3, 1968, the claimant agreed to accept $376,685 in full settlement of the claim for the loss of sheep, while reserving the right to submit an additional claim or claims for the additional damages suffered by him.

3. The settlement represented the valuation of 5,727 ranch ewes at $55 per head, or $314,985, 142 Suffolk ewes at $100 a head, or $14,200, 380 bucks at $125 a head, or $47,500, for a total of $376,685. The number of sheep lost was verified by an Army legal officers on the scene.

4. Of the total of sheep lost, 4,372 sheep died within a relatively short period after the incident and the remaining 1,877 became sick. Sick sheep were valued the same as dead sheep. Affidavits were submitted that the sick sheep were not marketable, nor likely to be marketable in the future even if they did recover. It was determined that payment for the sick sheep on the same basis as dead sheep was justified particularly in view of the claimant's statements that he had desired to destroy the sick sheep but was not allowed to do so by Army authorities and, as a result, incurred additional expenses in caring for these sheep. One theory was that they could be sold for dog and cat food. However, in view of their obvious contamination it was thought likely that no reputable manufacturer of dog and cat food would purchase the sheep.

5. The valuation of $55 per ewe was based on a purchase price of $30 per head, plus freight to the claimant's grazing area, plus grazing costs for 1 year. Wool and lamb production was added to this basic figure. The incident occurred at the conclusion of the producing season, during which an 8-percent loss of sheep is normally experienced. An 8-percent addition was made to the purchase price to enable the claimant to purchase the number of sheep necessary to produce the number lost at the end of the producing season. Market value of the ewe at the end of the producing season was deducted. This was a producing herd and it

was necessary to pay not only for the ewe killed, but also for the probable production from the ewe:

Purchase price of replacement ewes	$30.00
Freight	2.75
Cost of grazing at $1.50 per month for 12 months	18.00
Subtotal	50.75
Product of ewes:	
Wool clip, $5 less $1 shearing expenses	4.00
Lamb crop at $25 per hundredweight times average lamb weight of 90 pounds	22.50
Subtotal	77.25
Loss contingency of 8 percent of $30	2.40
Subtotal	79.65
Less market value of ewe at end of producing season	24.00
Net total	55.65

The value of the sheep was verified by qualified persons in the area and concurred in by the Department of Agriculture. After an initial misunderstanding, the valuation was concurred in by Mr. David R. Waldron, commissioner of agriculture, State of Utah. The majority of the sheep killed were descendants of a herd which had adapted to the ranch land in Skull Valley, Utah, over a period of 70 years. They had weight and production rates well above average. Most ewes were pregnant and all sheep were ready for shearing.

6. In addition to loss of sheep, the claimant incurred expenses in the claimed amount of $6,803.93: $2,732.50 for wages, $2,490 in veterinary fees, $1,281.43 for travel expenses, and $300 for telephone services. According to the ranch manager, there were other expenses relating to the sick sheep which were not claimed for. The claimant recovered $5,217.95 from the sale of wool shorn from 1,321 sick sheep, based on $4.70 for a 10-pound fleece minus $0.75 for shearing. These figures were confirmed as reasonable by the Department of Agriculture. It was agreed that the claimant would waive its claim for all expenses referred to in this paragraph, past and future including costs of disposal of the sheep, in return for allowing it to retain the proceeds from the wool sale from the sick sheep and their lambs.

7. The claimant also claimed for attorneys' fees of $35,000 to $52,500 plus $1,180.70 in other legal expenses. This was disallowed.

8. With regard to Dr. Osguthorpe's testimony, regarding sheep sold to the claimant during the fall of 1967, it has been determined that a sale of 1,674 sheep was made at that time. As these sheep were considered by the claimant to be of a lower quality than the average of the remainder of the claimant's approximately 15,000 sheep, they were distributed among his five herds. Accordingly, only a portion but not all of the 1,674 sheep were among those affected by the March 13, 1968, incident.

A complete copy of the file pertaining to the claim for $431,951.68 for the loss of 6,249 sheep plus miscellaneous expenses is being furnished to the subcommittee separately.

Mr. REUSS. My final question. Has that information about the chemical and biological budget arrived?

Dr. EMERSON. Yes.

Mr. REUSS. Would you now give it, please?

For what fiscal years? Let's have it for 1967, 1968, and 1969.

Dr. EMERSON. I have 1969.

Mr. REUSS. All right. What was is for 1969? Is that the only year you have?

Dr. EMERSON. Yes.

For smoke, flame and incendiaries, $138.1 million. For riot control munitions, $80.5 million. For herbicides, $5.2 million. For defensive equipment, $17.5 million. For a total of $241.3 million.

R.D.T. & E., $90.3 million. Operations and maintenance, $20 million.

Mr. REUSS. Is that the total?

Dr. EMERSON. Yes.

Mr. REUSS. What does that come to?

Dr. EMERSON. $351.6 million.

Mr. REUSS. That covers everything at Edgewood Arsenal and Fort Detrick and Dugway and other chemical and biological warfare bases?

Dr. EMERSON. Right.

Mr. REUSS. All the herbicides and defoliants used in South Vietnam?

Dr. EMERSON. Riot controls, flames, incendiaries.

Mr. REUSS. Thank you very much.

The subcommittee will now stand in adjournment until 2 o'clock in this room.

(Whereupon, at 12:25 p.m., the subcommittee was recessed to reconvene at 2 p.m. of the same day.)

AFTERNOON SESSION

(Whereupon, Dr. K. C. Emerson, Dr. Mortimer A. Rothenberg, and Brig. Gen. William W. Stone were recalled as witnesses and, having been previously duly sworn, were examined and testified further as follows:)

Mr. REUSS. The Subcommittee on Conservation and Natural Resources will be in order for further consideration of environmental pollution by the U.S. Government.

Counsel, you have some questions, I believe?

Mr. INDRITZ. Dr. Rothenberg, earlier this morning you testified, did you not, that you were first informed as to the death of the sheep on March 19?

Dr. ROTHENBERG. That is correct.

Mr. INDRITZ. Do you have a copy of the statement released by the Dugway Proving Ground at 3 p.m. on Thursday, March 21?

Dr. ROTHENBERG. No, not with me.

Mr. INDRITZ. Do you recall having seen such a statement?

Dr. ROTHENBERG. I believe I probably have seen such a statement; yes.

Mr. INDRITZ. Would these words probably have occurred in this statement, and I will quote: "At this time it would be purely speculative to attempt to fix a specific cause of death of the sheep. No other forms of animal life evidenced any symptoms whatsoever, although they are located in the same area where the sheep are dying"?

Dr. ROTHENBERG. Yes.

Mr. INDRITZ. Would you provide a copy of the full text of that statement for the committee records?

Dr. ROTHENBERG. I don't have a copy of that statement. I believe what you are quoting can be obtained—I am sure we have it in our records.

Mr. INDRITZ. Would you obtain it, please, and provide it to the committee?

Dr. ROTHENBERG. That is a copy of the statement——

Mr. INDRITZ. Released by Dugway Proving Ground at 3 p.m. on Thursday, March 21, 1968.

Dr. ROTHENBERG. I am sure we can obtain a copy of that.

(The text of the statement referred to follows:)

STATEMENT FOR USE IN RESPONSE TO QUERIES AND QUESTIONS, MARCH 21, 1968—DUGWAY PROVING GROUND, UTAH

The Army at Dugway Proving Ground, since Sunday, March 17, when it was notified of the problem by the University of Utah Ecology and Epidemiology Lab, has been cooperating with the university, the USDA, the Utah State Department of Agriculture, and private veterinarians in an effort to determine the cause of death of sheep in the Skull Valley area of Utah.

Medical, veterinarian, and other technical personnel of DPG are in the field investigating with these other agencies in an attempt to find some indication as to the cause and source of the problem.

All agencies are conducting laboratory analysis and field investigations appropriate to their capability. The Army is coordinating its effort with USDA representatives in Utah, and as information is developed it is being made available to interested agencies.

At this time, it would be purely speculative to attempt to fix a specific cause of death of the sheep. No other form of animal life has evidenced any symptoms whatsoever, although they are located in the same area where the sheep are dying (horses, cows, dogs, birds, rabbits). Until the investigation is complete the cause of death of sheep will not be known.

Mr. INDRITZ. What was your opinion as to the connection between the testing of nerve gas at Dugway Proving Ground and the death of the sheep as of Sunday, March 24?

Dr. ROTHENBERG. There was at that particular time no definitive diagnosis made of the cause of the incident. There was some concern, as I stated previously, that there might have been either natural bacterial or viral infection which had infested the herd and we did also initiate investigations to determine whether or not we were in any manner involved in this incident and had initiated as of Monday, which was the 18th—I am sorry, Sunday, the afternoon of the 17th, intensive investigation into the incident to determine just what the cause was, whether chemical, biological, or what have you.

Mr. INDRITZ. I will read from the text of the UPI story of March 24, on Sunday. It begins:

"Salt Lake City, Utah (UPI)—The Army emphatically denied Sunday any connection between testing of nerve gas at its secret Dugway Proving Ground and the death of 5,600 sheep in western Utah."

Is that a true representation of the Army's position at that time?

Dr. ROTHENBERG. I think General Stone covered this particular aspect of the public release in his own statement a while ago, and I think the statement made by General Stone indicated that there was some concern for Army involvement but there was no specific evidence linking this occurrence to activities at the proving ground.

Mr. INDRITZ. You said just a moment ago that the only concern that you had at that time was with reference to germ or virus—that is, bacteriological—infection.

Dr. ROTHENBERG. From the description of—yes. What I was referring to would have been the normal epidemiological experience in the area. There have been a variety of diseases that normally occur within the sheep herds.

Mr. INDRITZ. Are you saying that such diseases would not have been related to an organophosphate type of poisoning?

Dr. ROTHENBERG. There was no way of determining that at the time. This was under investigation. The investigation had started on Sunday.

Mr. INDRITZ. I will read another paragraph from this same UPI story of Sunday, March 24.

"Dr. Mortimer A. Rothenberg, Scientific Director at Dugway, said it was his experience that sheep exposed to toxic nerve agents suffered tissue quivering, salivation and depression of the blood. But he said none of the sheep tested thus far have suffered those symptoms to any great degree.

"Rather, he said, the dead sheep in Skull Valley suffered symptoms which would be expected in sheep exposed to organic phosphates contained in certain insecticides. He admitted, however, that nerve agents do contain certain organophosphate compounds."

Would it appear from this statement in the UPI story, assuming it was accurate, that you were then concerned about the connection of organophosphates with the sheep deaths?

Dr. ROTHENBERG. By that time we had some indication from our laboratory investigations and our university investigators to indicate that this was not a bacteriological or a viral material. This was some 10 days later.

Mr. INDRITZ. I am reading from the UPI story dated March 24.

Dr. ROTHENBERG. Yes; 11 days later.

Mr. INDRITZ. You testified a moment ago that as of March 24 you were concerned only with bacteriological infection.

Dr. ROTHENBERG. That is right. I don't have detailed dates in mind. I am sorry. It is difficult to reconstruct this. Let me look at the chronology as we have it recorded.

The information we have is that on Saturday, the 23d, with the arrival of some experts from Edgewood Arsenal and expert veterinarian assistant's pathological examination of the sheep indicated no pathology whatsoever which indicates that there was no biological involvement.

Mr. INDRITZ. That there was no biological involvement?

Dr. ROTHENBERG. This was the 23d.

Mr. INDRITZ. The 23d?

Dr. ROTHENBERG. Yes. I am sorry, I do not recall the exact sequence. I would have to go through these records in detail.

Mr. INDRITZ. Do I understand your testimony, then, that by the 23d you were beginning to view the cause of the sheep's deaths to be related to the organophosphates?

Dr. ROTHENBERG. Potentially related to the organophosphate.

Mr. INDRITZ. I call your attention to an article in the Deseret News of March 26, 1968, which states:

Dr. D. A. Osguthorpe told the Deseret News that birds, rodents, and at least one rabbit were found dead in the area where thousands of sheep died in Skull and Rush Valleys.

As of that date, had you come to any further conclusion as to the relationship between the sheep deaths and the dissemination of the nerve gas VX?

Dr. ROTHENBERG. Well, as indicated earlier, the dead animals which were brought into the proving grounds seem to have died of normal causes. They were fairly well desiccated and it was almost impossible to withdraw a sufficient amount of blood for analysis in the laboratory to determine whether or not there had been any actual cholinesterase level depression, any depression in blood activity level.

Mr. INDRITZ. But as of that date you were still denying that there was a connection between——

Dr. ROTHENBERG. Well, there are normally a variety of animals found dead in the desert and simply because there are animals, dead animals located there does not indicate a direct relationship to any activity which had been underway.

I think it might be of interest to note that as part of our ecology and epidemiology program an animal trapping and survey study had been performed in the Skull Valley and Dugway and surrounding environs, I might add, early in the month of March somewhere—and I do not have the exact date in mind but I can dig it up—somewhere around the 5th or 6th of March, and population densities were determined for the variety of the normally occurring rodents, wildlife in the area, and so on. After the incident had occurred, we requested that our contractor go out once again and do an additional survey which was accomplished somewhere around the 29th of March and his findings were that there were no changes in rodent population densities in the area.

Mr. INDRITZ. Doctor, when in fact did the Army come to the conclusion there was some connection between the nerve gas dissemination and the sheep death?

General STONE. Can I step in?

Mr. INDRITZ. Please do.

General STONE. The way I have always visualized this was that this was a gradually evolving picture; bits and pieces of evidence were coming in.

As I mentioned earlier, a lot of this was negative evidence which was eliminating more and more of the other possibilities of what might have happened. There was very little in the way of positive proof that this was what in fact happened. The first bit of positive evidence that I know of where every one of the scientists were completely satisfied that it was acceptable evidence—and, as you realize, there are always differences of opinion among competent scientists as to what is sufficient evidence—was, I believe, about the middle of May, when there were some chemical analyses made which did positively identify the material. Such a statement is in Dr. Emerson's prepared statement—although I am not sure of the date, this was, from my personal point of view, the first bit of evidence I had that I felt was truly positive evidence.

The presumptive case had already been built. It was gradually building over this period of time.

Mr. INDRITZ. Dr. Emerson, earlier this morning the chairman asked if you were aware of the fact that Du Pont Co. manufactures the red dye that is used in the test applications at Dugway, and I am not sure that I recall your exact answer. Did you say that it did?

Dr. EMERSON. I am not sure what I said this morning, but I made inquiries at noon and we do procure it from there. The amount involved over the years has been less than 100 pounds at a cost of $1.76 per pound.

Dr. ROTHENBERG. The material is used as a tracer. No more than something like six-tenths of 1 percent is used.

General STONE. If I might interrupt again, sir, the material is used in order to have a visible cloud that you can photograph and keep track of it for test purposes. The photographs that Dr. Osguthorpe saw were photographs of this oil dye being dispersed, with the agent. The tracer material was Du Pont oil, red.

Mr. REUSS. In that connection, how did this test on March 13, 1968, come off—did it go according to plan, or did something go wrong?

General STONE. No, sir; there was a malfunction in one of the tanks. When the tanks function there is a plate that opens on each end. One plate did not open completely and the material came out slower from one tank than it did from another. This was the reason why the material dribbled out over a period of time including the period after which the pilot had started to pull up. He was beyond the edge of the instrumented target.

Mr. REUSS. Mr. Carlson, did you have something you wanted to ask?

Mr. CARLSON. No, thank you.

Mr. REUSS. Thank you very much, gentlemen.

(Witnesses excused.)

Mr. REUSS. We will now hear from Dr. William H. Stewart, U.S. Surgeon General.

Thank you very much for your patience, Dr. Stewart.

We have your statement which under the rule will be admitted into the record.

Will you now proceed, sir?

Dr. STEWART. Thank you, Mr. Chairman.

STATEMENT OF DR. WILLIAM H. STEWART, SURGEON GENERAL, U.S. PUBLIC HEALTH SERVICE, DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE

Mr. Chairman and members of the subcommittee, as part of the Army's response to the death of sheep in the vicinity of Dugway Proving Ground in March of 1968, the Secretary of the Army established an Ad Hoc Interagency Advisory Committee for Review of Safety Testing at Dugway Proving Ground.

The committee was requested to review the procedures, talents, monitoring equipment, facilities, and safety regulations used by Dugway Proving Ground in connection with chemical tests. The purpose was to determine whether safety measures are adequate to insure that chemical tests at Dugway Proving Ground do not constitute a hazard to humans, animals, and plants outside the proving ground or in the housing and administrative areas within the proving ground. The committee was requested to make such recommendations as it deemed necessary to protect the public health.

I was asked to serve as chairman. I agreed—not because I possess particular expertise in chemical testing procedures, which I do not—

but because as Surgeon General I have responsibility within the Federal Government for protection of the public health. Membership of the committee did include recognized authorities in chemical testing from the Department of Agriculture, Commerce, Interior and Defense. Also included were officials from the Utah State Departments of Health and Agriculture and a civilian scientist from the academic community.

The committee visited Edgewood Arsenal, Md., and received a comprehensive briefing on the physical and medical aspects of chemical agents of interest that are currently being field tested at Dugway Proving Ground or planned for test in the foreseeable future. Methods of agent dissemination and defensive aspects of chemical testing were discussed. Dugway Proving Ground, Utah, and Deseret Test Center, Fort Douglas, Utah, were visited and the committee was briefed in depth on all aspects of the chemical test program, current and proposed. Details of a recently developed aggressive program of research and technology to further assure safe testing at Dugway Proving Ground, program SAFE later to be called SAFEST, were presented. The group toured Dugway Proving Ground and inspected the technical, scientific, and medical facilities, talked with key scientific and engineering personnel and reviewed Dugway's safety procedures and regulations. The committee held a number of meetings in the Washington, D.C., area. In addition, several members made independent site visits for additional technical conversations.

For certain classes of chemical agents and munitions, the committee agreed unanimously that current field test procedures and practices were both sound and adequate. The committee found, however, that for field testing of certain other classes of chemical agents and munitions, additional steps must be taken to insure the adequacy of test procedures and practices. The committee then indicated what these additional steps must be. I will go into details of these recommendations later in my statement.

In terms of desirable safety restraints, chemical test programs can be identified under one of five headings. The headings are riot control agents, incapacitating agents, nonpersistent lethal agents, persistent lethal agents, and new yet untried agents. Under the "new agents" heading fall those future test programs in which the newness of the agent may require special safety restraints. For this reason the ad hoc committee could not and did not attempt to address itself to this heading. Under the first three headings—riot control agents, incapacitating agents and nonpersistent lethal agents—the committee did conclude that current operating practices and restraints are adequate to support all tests currently programed.

This leaves for consideration the heading of persistent lethal agents. The basic principle underlying the safe conduct of any chemical test is the eventual depletion and dilution of the toxic material by natural processes by the downwind travel of the cloud over controlled areas. At Dugway, the largest controlled area is the salt flats area to the northwest of the major test grids. Therefore, large scale testing of persistent lethal agents should be designed and executed in a manner which insures the depletion and dilution of the cloud within the controlled salt flats area. This restriction should remain

until studies of vegetation, soils, and wildlife and an increased Dugway meteorological capability indicate this restriction can be modified safely.

Since your committee has asked specifically about persistent chemicals, I think it worthwhile, therefore, to restate at this time the committee's recommendations for test limitations on these agents. These recommendations were:

(*a*) Testing of persistent lethal agents and munitions in quantities of agent not to exceed the equivalent of one artillery round, rocket, or mine be resumed without modification of current practices and safety procedures. The scale of testing must be consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man, representative indigenous animals and domestic livestock.

(*b*) Plans of test for programs involving persistent lethal agents in quantities greater than those specified above, will specify restraints in scope of testing and meteorological restrictions needed to comply with the following criteria: (These restraints should remain in effect until reviewed by a permanent Chemical Safety Committee.)

(1) The combination of windspeed, release height, and particle size shall be controlled to provide maximum depletion of the cloud within the initial downwind travel period. No release shall be made at heights greater than 300 feet; also, no significant fraction of the agent cloud shall be composed of particles smaller than 100 microns in size. Positive control of agent dissemination will be maintained by automatic flow devices, radar and radio control, by establishment of limitations on total quantity of agent dispersed and other available means when high-performance aircraft are used for dispensing toxic chemical agents having properties equivalent to those of the nerve agent VX.

(2) The cloud shall remain in a sector between north and northwest of the test area and not cross U.S. Highway 40 for at least 3 hours.

(3) The windspeed at standard anemometer altitudes (10 to 30 feet) shall be as low as possible but no stronger than 15 miles per hour.

(4) No thunderstorms shall be present within 100 miles of the test site at release time nor predicted to occur within 100 miles of the cloud trajectory for at least 8 hours from actual release time.

(5) Confidence in the weather forecast shall be high; there must be past experience demonstrating the reliability of predictions from similar weather situations.

Atmospheric processes play a vital role in the safety program at Dugway Proving Ground. Once the mode and amount of agent release has been prescribed for a test, a plan is sought to see if and how the atmosphere may provide the necessary degree of safety. Several processes can achieve dosages in uncontrolled downwind areas which would be considered nonhazardous.

(*a*) Maximize deposition over controlled areas: A number of factors control the fraction of the solid or liquid agent which settles out over a nearby controlled region.

(1) The height of release: The lower the altitude, generally speaking, the sooner the deposition. Therefore, it was recommended, for example, that no release take place at heights over 300 feet above terrain.

(2) The particle or droplet size and density: The larger and heavier the mass, the faster it falls. Every effort should be made to disperse agents as particles or droplets larger than 100 microns. Particulates or droplets at 100 microns or greater fall from 300 feet to the ground in about 5 minutes according to Stokes' Law.

(3) The windspeed which determines the transport distance during descent: By selecting low speeds, one improves the chances for deposition near the point of release. Therefore, it was recommended that windspeed be no stronger than 15 miles per hour at standard anemometer altitudes.

(*b*) Control cloud trajectory and maximize dilution. Since the height of release and nature and amount of agent will be prescribed by test requirements, only atmospheric parameters remain flexible. Two aspects of air motion should be distinguished:

(1) The mean wind bodily transports the whole cloud: By selecting appropriate mean wind directions, the cloud may be confined to a preassigned downwind sector. This sector may lie to the north and northwest of the Dugway test areas. The extensive controlled area of the Dugway Proving Ground is supplemented by the Wendover Bombing Range. This sector contains little vegetation, no domestic animals and no people until Highway 40 is reached. Further, winds blowing generally from the south-southeast into this sector occur with moderate frequency.

(2) Turbulent winds which dilute the cloud thereby reducing the maximum concentration: Changing wind direction and/or speed with altitude enhances horizontal cloud growth while vertical convection as occurs on hot afternoons increases vertical diffusion.

To insure maximum deposition over a controlled area along with controlling the cloud trajectory and maximizing dilution was the basis for restrictions 1 to 5 under "Test Limitations" of the committee report. Under these conditions there would be no hazard to anything on U.S. Highway 40, 3 hours after the test.

I would like to set in proper perspective the problem of knowledge gaps which are identified either explicitly or implicitly in the recommendations I have just cited. Much of the information which the committee categorized under toxicological research, environmental studies, meterological, and medical is already known. Much of what is known already is being applied in the Army chemical testing program. Undoubtedly there is need for additional knowledge and in recognition of this need, the ad hoc committee clearly stated that current test programs should be continued under specific restrictions. The committee made clear that if the Army wishes to reduce these restrictions on its testing activity, it must first undertake research required to prove the restrictions unnecessary.

The final acquisition of all knowledge applicable to the test program is complex and time consuming. In view of this fact, the Department of Defense must decide the relative scale of effort justified in order to reduce testing restrictions.

The committee never addressed the subject of confinement of tests of lethal agents to test chambers and confinement of open-air testing to analogous, nonlethal substances. This type of question was not considered within the scope of the purpose or competence of the committee.

In support of the toxic agent open-air test program, I understand that the Deseret Test Center chemical/biological accident/incident control plan—including mass casualty and medical evacuation procedures—has been revised in accordance with the ad hoc committee recommendations. Utah State health and local officials participated in the planning and exercise of this revised plan. The Governor of the State and Utah State director of health are given regular periodic briefings on all of Deseret Test Center's planned testing.

In closing, Mr. Chairman, I would emphasize that the ad hoc committee was organized to make recommendations which would insure that testing of chemical agents by the Department of the Army was carried on in such a manner as not to endanger the public health. The committee had no other function and no other charge. It completed its review and made recommendations as of November 1968. With this report the ad hoc committee was resolved and my connection with the testing program ended.

The permanent Chemical Safety Committee recommended by the ad hoc committee has been established and the first meeting was held May 1 and 2, 1969, at Deseret Test Center, Fort Douglas, Utah. I believe it would be most desirable for this permanent committee to issue periodic public reports on progress and problems in meeting deficiencies described in the ad hoc committee's report.

That concludes my testimony, Mr. Chairman.

Mr. REUSS. Thank you, Dr. Stewart.

You have testified that the interest of your committee was solely in chemical tests?

Dr. STEWART. That's correct.

Mr. REUSS. It was not concerned with possible effects on the environment of biological tests in the environment?

Dr. STEWART. No, sir; it was not.

Mr. REUSS. Were you aware before these hearings commenced yesterday that there exists an area, just outside the immediate Dugway Proving Ground, designated on an armed services map as "Permanent Biocontaminated Area"?

Dr. STEWART. Not until I read it in the newspapers yesterday, I guess it was. And then I saw it on the map today.

Mr. REUSS. Will you observe the location of that "Biocontaminated Area" on the map which is now being presented to you?

(Map handed to Dr. Stewart.)

Dr. STEWART. Yes, sir; I see it.

Mr. REUSS. And will you now look at the map, listed as appendix A in your Interagency Ad Hoc Advisory Committee report? There is on the map, listed in your report as appendix A, a dotted line which encloses an area of—oh, from east to west it's—I make it some 48 miles from east to west.

Dr. STEWART. The boundaries of Dugway.

Mr. REUSS. Is that about right?

Dr. STEWART. Yes; I think that's correct.

Mr. REUSS. And it is not the area designated "Permanent Biocontaminated Area" in the armed services map, which is in the record of these proceedings and which you are now looking at, in fact within the boundaries of the area as indicated on appendix A, your map?

Dr. STEWART. Well, as near as I can tell; yes, it is.

Mr. REUSS. Well, will you confirm that, please?

Dr. STEWART. Yes; I would say it is; yes.

Mr. REUSS. It is within the Dugway area?

Dr. STEWART. I think so.

Mr. REUSS. Dr. Stewart, there has been testimony before this subcommittee that the lethal effect of the VX exposed to the environment at Dugway on March 13, 1968, lasted a considerable length of time; at least 3 weeks to a month. In one verified case a sheep theretofore in good shape was fed forage from the Skull Valley range, and promptly died. Numerous other sheep displayed a significant lowering of their cholinesterase level.

Dr. STEWART. I would think that was compatible with our knowledge of the chemical substance.

Mr. REUSS. This stuff lasts for a long time, and kills for a long time?

Dr. STEWART. Yes. That's getting out to the outer limits. The curves that you see of the chemistry—this substance hydrolizes, and, of course hydrolysis depends on the availability of water. And then it varies with temperature. In the test tube you can get curves and you can predict in the field, this amount of time would be compatible with those curves.

Mr. REUSS. But there really is no better evidence, is there, than a lot of dead sheep, 20 or 30 days after the event, whose tissues show lethal doses of VX?

Dr. STEWART. That's quite right.

Mr. REUSS. VX is a very deadly and very persistent chemical?

Dr. STEWART. Persistent and deadly; that's correct.

Mr. REUSS. What is there to stop the VX from descending to the soil in the test area on the day of the test, and then days later being caught up by winds of high intensity, which could not have been predicted by any meteorological method at the time, and being swept into Highway 40, a few miles north of the area, or to Salt Lake City, or the big population complexes 80 miles to the east?

Dr. STEWART. Well, there is nothing that would have prevented it. The whole purpose of the testing, however, Mr. Chairman, is to make the dose of the test fall on the test grid. None of it is ever that perfect. If they had a perfect test, 100 percent of the substance would fall on the test grid, which is usually 2 miles square. There is always some that becomes the cloud that we talk about.

Mr. REUSS. Well, even as to the amount which falls on the test grid, what is to prevent that, a day, a week, 3 weeks later, from being caught up by winds and thence carried to areas where it can kill people?

Dr. STEWART. Well the test grid, of course, is a controlled area. And you can test to see if the substance is present; you can wet it down, and it would be perfectly all right; you can burn it; you can do anything. You have a control on the test grid itself.

Mr. REUSS. Well, supposing some of the same gentlemen who were conducting the tests on March 13, when it did kill 6,000 sheep, leave it

lying around the area of deposition inside and outside the test grid, and a wind comes along a couple of days later?

Dr. STEWART. It's conceivable, Mr. Chairman, that what you're saying could be so. Material in the test grid is under such control that I just cannot conceive of that.

What happened with the sheep was that it was the portion that was uncontrolled, that they had no control on.

Mr. REUSS. You have just testified, however, that there is nothing really to stop some of this material from getting outside the test grid. How about, for example, the material that goes on this dandy 3-hour trip to Highway 40 and conveniently expires beforehand? What's to prevent it from getting churned up by the first more-than-15-mile-an-hour wind that comes along?

Dr. STEWART. Well, that material has never been on the ground yet, Mr. Chairman. That material got there after it was released at a certain height. The particle sizes were over 100 microns. There was a 15-mile-an-hour wind at ground level, or up to 30 feet. There were no washouts from rain.

Mr. REUSS. You are talking about the March 13——

Dr. STEWART. No; I'm talking about the Highway 40 that you mentioned. What we are talking about is the residual cloud which has not reached the ground yet, because these are the small particles that drift along and will go on and on and on.

Mr. REUSS. You say that it is your hope that the original cloud heading for Highway 40 at not more than 15 miles an hour will have deposited its material before it gets to Highway 40, and hence won't kill people on Highway 40?

Dr. STEWART. Mr. Chairman, it is not a hope; we take this very seriously.

Mr. REUSS. It's your belief?

Dr. STEWART. It's our best judgment that with all the knowledge we have, following these restrictions that we have put on, that by the time that cloud passed Highway 40 it would be harmless.

Mr. REUSS. It would be harmless because the particles of VX would have been deposited out of the cloud?

Dr. STEWART. Most of it would have been deposited on the grid, and the cloud itself would have been churned and dispersed by the time it crossed Highway 40. And it may go on another several hundred miles.

Mr. REUSS. But by that time the cloud will be purified of its lethal contents?

Dr. STEWART. Not necessarily—yes, purified of its lethal contents. It's down to a few molecules.

Mr. REUSS. So we have cleared up that cloud. The cloud goes on its innocent way, having made its 15-mile-an-hour trip to Highway No. 40 and taken 3 hours to get there.

Dr. STEWART. Right.

Mr. REUSS. So nobody is killed by that cloud. And the reason nobody is killed by that cloud is that the VX particles were deposited out of it on its way to Highway No. 40. And by Highway No. 40 you feel that all would have dropped to the ground?

Dr. STEWART. Correct.

Mr. REUSS. Well, what is to stop a strong and unpredictable wind—the next day, or the next week, or 3 weeks after—from coming

along and whipping up those particles which had obligingly dropped out of the first cloud, and then depositing them on people who are using Highway No. 40?

Dr. STEWART. If they have followed the other restrictions we have, the other deposits would have been almost entirely on the grid itself. And this is a controllable area. There would have been a small amount depositing itself all along the way. But the design of the test, if they followed these restrictions, is such that a 100-micron particle will fall out at 300 feet, with this wind speed, in 5 minutes; which is about 2 miles.

Mr. REUSS. And the grid area is——

Dr. STEWART. About 2 miles.

What you have is, you don't have any absolute perfect particle size mix. You have some, a small proportion that is smaller. They drift. They don't fall.

Mr. REUSS. Well, let's talk about these little fellows. They are still lethal enough to kill sheep, men, and everything else; aren't they?

Dr. STEWART. If they got enough of a dose, yes; there is a dose-response relationship.

Mr. REUSS. Well, what is to stop—under your new testing procedures—what is to stop a strong wind from coming up a day, a week, 3 weeks, a month later and catching up these unneutralized particles and depositing them upon people on Highway No. 40 or in Salt Lake or anywhere else?

Dr. STEWART. In the control area, Mr. Chairman, these can be neutralized right then because they are controlled. The amount that would be deposited elsewhere along the way would be infinitesimal. And, of course, it is hydrolyzing all along the line. It is deteriorating all the time from the moment of release on.

Mr. REUSS. Well, it certainly didn't deteriorate on the plants fed to sheep which then killed the sheep a month afterward.

Dr. STEWART. Yes, sir; but that was not under the controlled conditions that we have recommended.

Mr. REUSS. Yes, but your controlled conditions apply to this 2-mile grid. What about the remaining 28 miles until you hit Highway No. 40?

Dr. STEWART. But the sheep-kill was still aimed at that 2-mile grid. The test was aimed at that grid. It just did not go on the grid, all of it, like it was supposed to.

Mr. REUSS. Yes, but you have indicated that even a perfect test under the new rules will allow some particles, the smaller particles particularly, to hit the ground in the 28 miles from where the grid ends to where the U.S. highway starts.

Dr. STEWART. Yes.

Mr. REUSS. And you use that as an earnest of your faith. You have said, "Don't spew it out if it is going to get to Highway No. 40 in under 3 hours," so you use that as an earnest of your faith in that test. The question that I put to you is:

Recognizing that you feel that some of these particles are going to land on the ground outside of the grid area on the way to Highway

No. 40, I ask, what is to stop those particles from later being airborne and continuing on their deadly journey?

Dr. STEWART. They are not even depositing on Highway No. 40. They are passing beyond it.

Mr. REUSS. VX passes beyond Highway No. 40?

Dr. STEWART. Well, any cloud will go on forever until it hydrolyzes.

Mr. REUSS. I thought you had testified that the clouds you were willing to see pass Highway No. 40 had to be rid of their VX content.

Dr. STEWART. Oh, no. They may have a molecule of VX in them still. There is still a cloud of VX.

Mr. REUSS. Well, isn't this a continuing process with a declining curve and doesn't the greatest amount fall to the earth in the first 2 miles in the grid where it can be tidied up?

Dr. STEWART. Correct.

Mr. REUSS. And then doesn't a smaller amount fall to the earth outside the grid where it does not get tidied up?

Dr. STEWART. And some may never fall to the earth——

Mr. REUSS. Yes.

Dr. STEWART (continuing). Before it is hydrolyzed.

Mr. REUSS. We won't worry about that. But what about that which does fall to the earth in the 28-mile area between where it is subject to tidying up procedures and where Highway No. 40 crosses the line of flight?

Dr. STEWART. If they follow the restrictions that we have placed on them, the amount that will fall there will not be toxic in our judgment.

Mr. REUSS. In your own report on page 26 you had this to say:

> (a) It is well known that some particles on the ground are resuspended by the action of a strong wind which can occur at Dugway Proving Ground. Some soil or other particles in the test area may be heavily contaminated by chemical agents. While it is the opinion of many that off-post hazard from such resuspension of contaminated soil is inconsequential, the matter deserves experimental confirmation.

Dr. STEWART. We agree with that; yes.

Mr. REUSS. That is your own statement?

Dr. STEWART. That's correct.

Mr. REUSS. How about getting to the people in the United States, particularly those who use Highway 40, that experimental confirmation before we test?

Dr. STEWART. When the wind blows up the sand or the dirt with the molecule, the couple of molecules of VX attached to it, of course it's a much different kind of weight and mass than it would be if it were VX itself and therefore its transport can be minimal or large. It has been hydrolyzing increasingly.

As I said at the very beginniing when you asked, Mr. Chairman, it is conceivable that what you say could happen. It could draw up and move the dust and dirt of the small amount that is passed off after the grid. It is conceivable.

We thought that they should do some testing of the soil itself and persistence in soil and we have so recommended.

Mr. REUSS. But meanwhile, you are letting them go ahead with their testing before they have made this experimental confirmation, are you not?

Dr. STEWART. We think if they follow the restrictions that we put down the testing will be safe to the people of the area.

Mr. REUSS. On page 10 of your statement, Dr. Stewart, you say this:

> The committee never addressed the subject of confinement of tests of lethal agents to test chambers and confinement of open-air testing to analogous non-lethal substances. This type of question was not considered within the scope of the purpose or competence of the committee.

Dr. STEWART. Yes.

Mr. REUSS. Why in the world wasn't it within the scope of your committee's responsibilities?

Dr. STEWART. Well, the purpose of testing, of course, is to test whether it is a good weapon or not, and we are not weaponeers. If they are going to test in the way they have been testing then we would say that it should have these kinds of rules and regulations that we put into our report.

They do chamber-testing of course a great deal before they start doing field tests but the decision of whether you field test or not is really related to whether it's a weapon or not, or defense against a weapon, one or the other.

What we were saying is that you pick the right kind of test, whether it is for a weapon or a defense against a weapon. But if you choose this kind of test, these are the restrictions you must have. That latter part is what we addressed ourselves to.

Mr. REUSS. And as far as you and the other non-military scientists on the committee are concerned, for all you know the military efficacy of these weapons may be as well tested in test chambers?

Dr. STEWART. This may be so, Mr. Chairman. We don't get into whether it would have been better to have tested a weapon this way rather than that way.

Mr. REUSS. What's the name of your Atlanta laboratory?

Dr. STEWART. National Communicable Disease Center.

Mr. REUSS. The NCDC made tests of these sheep cadavers in April 1968, did it not?

Dr. STEWART. That's correct.

Mr. REUSS. And those tests conclusively show that those sheep died of VX nerve gas, did they not?

Dr. STEWART. We thought it was conclusive but there was some dispute.

(Subsequently, Dr. Victor W. Sidel, who appeared before the subcommittee on May 20, 1969 (the first day of these hearings), and Dr. Stewart submitted the following statements at the request of the subcommittee staff:)

SUPPLEMENTARY STATEMENT, BY INVITATION, OF VICTOR W. SIDEL, M.D.

Certain statements in the testimony by Dr. William H. Stewart, Surgeon General of the U.S. Public Health Service, at these hearings in my opinion require further analysis. In response to a question about the persistence of lethal material in a toxic cloud passing over Highway 40, Dr. Stewart said the cloud would

be "purified of its lethal contents. It's down to a few molecules." A few minutes later, in response to another question on clouds passing Highway 40, Dr. Stewart said: "They have a molecule of VX in them still. There is still a cloud of VX." Finally, in discussing the possibility of soil or other particles in the ground being resuspended by the action of a strong wind, Dr. Stewart said: "When the wind blows up the sand or the dirt with the molecule, the couple of molecules of VX attached to it. * * *"

If one calculates the number of molecules of VX required to kill, these statements by Dr. Stewart about the number of molecules which might reach Highway 40 are extremely reassuring. For example, let us assume (1) that the molecular weight of VX is about 150 (from the material in the open literature it is clear that the molecular weight is at least 120 and probably in the range of 150 to 200) and (2) that an LD_{50} for man (the amount which will kill about 50 percent of the human beings exposed to it) is about 5 milligrams (from the open literature it appears that the LD_{50} may be between 1 and 10 milligrams). Since one gram molecular weight (mole) of a substance contains 6×10^{23} (that is, a 6 followed by 23 zeros) molecules, 150 grams of VX would contain this number of molecules. Five milligram of VX would therefore contain approximately 20×10^{18} molecules (that is, 20 billion billion molecules). Thus, some 20 billion billion molecules of VX seem necessary to kill a human being and the suggestion by Dr. Stewart that only "a molecule," or "a few molecules" or a "couple of molecules" would be left in the cloud or resuspended with blown soil are reassuring indeed.

However, if one examines these statements more closely, some of the reassurance disappears. Dr. Stewart indicated that the disappearance of the lethal material from the cloud occurs (1) by deposit on the test grid; (2) by deposit on the 35 miles between the grid and Highway 40; and (3) by hydrolysis. Let us make the following assumptions which, if anything, err in the direction of minimizing the dangers: (1) that 99 percent of the VX is indeed deposited on the grid; (2) that 99 percent of the remainder is indeed deposited between the grid and the highway; (3) that 99 percent of the remainder is indeed hydrolysed; and (4) that none of the deposited material is resuspended. Using these assumptions, only 1 millionth (1 percent x 1 percent x 1 percent) of the original lethal material will remain in the cloud reaching Highway 40. How many molecules does this represent? Let us assume that 1 ton of VX is used in a test (the amount sprayed by airplane in the March 1968 test was 320 gallons—over 2,600 pounds, if the material has the specific gravity of water; in addition, it has been noted in the open literature that 4- to 5-ton chemical warheads have been developed for strategic ICBM's and that the Sergeant tactical missile can carry a 1,000-pound chemical payload). Four billion billion billion molecules would thus be released in such a test (based on 2,000 pounds in a ton; 454 grams in a pound; 6×10^{23} molecules in each 150 grams of VX). If 1 millionth of these remain lethal and in the cloud reaching Highway 40, there would still be 4,000 billion billion lethal molecules in that cloud. This is a somewhat different picture than that given by "a few molecules" or "a molecule."

How much lethal material does this represent? If one divides the 4,000 billion billion molecules in the cloud by the 20 billion billion molecules needed to kill there are still 200 times the lethal dose in the cloud under the assumptions specified, and these assumptions would tend to minimize the danger. Please note that I am not suggesting that there is any great likelihood that these molecules will all fall on Highway 40 or that these molecules would be concentrated enough in the cloud to be lethal. I am suggesting, however, that Dr. Stewart's extremely reassuring statements about the number of lethal molecules in the cloud passing over Highway 40 are unlikely to be correct. In like fashion, it seems unlikely that only a "couple of molecules" would be blown up with particles of sand or dirt; the overall number is much more likely to be in the multiple billions.

This apparent understatement of the number of molecules is disquieting to me as a matter of principle. It would appear to me to be the duty of the U.S. Public Health Service not to understate in any way the potential dangers to the public health of development, stockpiling, testing, or use of these weapons. The Congress, or the Army, presumably may decide that great risks must be assumed because of another purpose that is within their purview; but they should, in my opinion, be given in-no-way-understated estimates of the potential danger to the public health on which to base their balancing of potential risks against presumed benefits.

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE,
Washington, D.C., June 19, 1969.

Hon. HENRY S. REUSS,
Chairman, Conservation and Natural Resources Subcommittee,
Committee on Government Operations,
House of Representatives,
Washington, D.C.

DEAR MR. CHAIRMAN: I am happy to respond to the request of June 13 from the professional staff of your committee. I do appreciate receiving a copy of Dr. Sidel's review of my remarks made at the Conservation and Natural Resources Subcommittee hearings on May 21 concerning air testing of the nerve gas VX.

When the committee which I chaired examined the problem of the safety of testing at Dugway Proving Grounds, it concluded after examining all relevant data that the restrictions on air testing of quantities of VX above one artillery round in size, if properly carried out, would not result in a cloud passing U.S. Highway 40, which would be toxic. I see nothing in Dr. Sidel's review of my remarks that would make me feel that the committee would change its recommendation.

Since the review of safety procedures at Dugway is a continuous process you will note that one of the recommendations made by the committee which I chaired was that a permanent chemical safety review committee be established. This committee has been established as you know and I am informed that it has had its first meeting. I will refer Dr. Sidel's comments on my testimony to that committee for their future review and evaluation.

Sincerely yours,

WILLIAM H. STEWART,
Surgeon General.

Mr. REUSS. Mr. Gude.

Mr. GUDE. In your opinion, with respect to the effects of this VX material on either laboratory animals or human beings or with respect to the residual effects of the material, what would happen to it in the atmosphere? Do you know any reason from a medical viewpoint why you should have field testing rather than laboratory testing?

In other words, could these experiments be effectively conducted in a closed laboratory?

Dr. STEWART. Yes, you could test in a closed laboratory or in open tests but the reason for testing is for reasons of either a weapon or a defense against a weapon and whether a chamber test would be better to test a weapon or a field test is not our business.

If they are going to field test, though, these are the kinds of precautions they should take.

Mr. GUDE. As far as the effectiveness of this material as a lethal agent in killing people or animals, could you not arrive at the same determination in a laboratory?

Dr. STEWART. You're quite right. The toxicology effect on man and animal could be determined in a laboratory, almost all of it, and its persistence in soil under varied conditions and so forth.

Mr. GUDE. And the effects of convection currents and moisture and temperature and other related factors could be tested in a laboratory, could they not?

Dr. STEWART. Yes; definitely. And it is, actually.

Mr. GUDE. It is tested in a laboratory?

Dr. STEWART. Yes.

Mr. GUDE. Do we have such laboratories in this country?

Dr. STEWART. Well, Edgewood Arsenal is the laboratory where much of the toxicology on this material is done. Since this material is a country cousin of organophosphate pesticides of course there is a great deal of toxicology of pesticides which is related to the toxicology of VX.

Mr. GUDE. Then the reason why the Army prefers to field test this is unknown to you, except that it may be for some military reason?

Dr. STEWART. Well, I assume—and I am no military expert—that the delivery system itself has to be tested. I don't know how to test—what do you call it?—howitzer shells in a chamber as a delivery system, you see, and that's an example of what I mean.

Mr. GUDE. Concerning the physical qualities of VX, to your knowledge could these be simulated with nontoxic material or very low toxic material in a howitzer shell for field purposes?

Dr. STEWART. Yes, sir; it very much is. And many of the experiments and research we have asked them to carry out to lift the restrictions would have to be carried out first with simulants to find out what would happen. They use simulants a great deal.

But again they are using it from the standpoint of sort of a nonlethal trial of a weapons system that they wish to try. Our whole purpose here was, if you do such-and-such a trial, these are the precautions you should take.

Mr. GUDE. Yes; I understand that. But to your knowledge there is no reason why the results which would be obtained at Dugway in an open-air test could not be verified or obtained in a laboratory under laboratory conditions?

Dr. STEWART. If you are talking about its effect on animals and man I would say I know no reason. But I don't know enough about——

Mr. GUDE. Wouldn't the other factors—for instance the residual quality of the soil, the effects of air and temperature—also be amenable to laboratory experimentation?

Dr. STEWART. That's true; yes. You can do that in a laboratory. I might want to do some of the soil testing and testing on plants in the field because you have varied temperatures and humidities during the day and night cycle.

Mr. GUDE. Could this be done in a laboratory?

Dr. STEWART. You could do a lot of it in a laboratory.

Mr. GUDE. Thank you.

Mr. REUSS. What can't you do in a laboratory?

Dr. STEWART. You cannot deliver it with a 600-mile-an-hour aircraft.

Mr. REUSS. Do you need to deliver the VX gas as it was delivered on March 13, 1968?

Dr. STEWART. Well, again you are getting into a weapon and I just don't know about that.

Mr. REUSS. What dosage of VX is necessary to kill a man?

Dr. STEWART. I don't know. I could find out for you.

Mr. REUSS. Would you give it in milligrams, molecules, or whatever it may be?

Dr. STEWART. Yes.

Mr. REUSS. Just one more question: Were any tests made of the cholinesterase levels of the sheepherders out in the Skull Valley area?

Dr. STEWART. It is my understanding there were. I believe that was the State health department; the Public Health Service may have helped them on it.

Mr. REUSS. But you don't know what the result of that was?

Dr. STEWART. No; but I can get that from Dr. Thompson.

Mr. REUSS. If you would, and make it available to us.

Thank you very much, Dr. Stewart, for your help, and also for your patience.

(Witness excused.)

(Subsequently, the following data were submitted by Dr. Stewart:)

DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE,
PUBLIC HEALTH SERVICE,
Washington, D.C., May 28, 1969.

Hon. HENRY S. REUSS,
Chairman, Conservation and Natural Resources Subcommittee, Committee on Government Operations, House of Representatives, Washington, D.C.

DEAR MR. REUSS: This is in response to a request for additional information during my appearance before your subcommittee May 21, 1969.

The first request concerned the dosage of VX which is fatal to man. The Department of Defense advises this information is classified "secret." Officials there indicated, however, they would be happy to provide the information if you will contact DOD directly.

I was also asked to provide data from blood tests given to sheepherders and other residents in the area of the sheep-kill. These tests were made by the Utah State Division of Health, and a copy of their report is enclosed.

If you have further questions, I will be happy to respond.

Sincerely yours,

WILLIAM H. STEWART,
Surgeon General.

UTAH STATE DIVISION OF HEALTH, UTAH COMMUNITY PESTICIDE STUDY RESPONSE TO THE SKULL VALLEY SHEEP INCIDENT, PRESENTED AT THE ANNUAL PROJECT DIRECTOR'S MEETING—ATLANTA, GA., JANUARY 19, 1969

(By Stephen L. Warnick, Ph. D., principal investigator)

During the week of March 14–20, 1968, the Utah State Division of Health received reports that thousands of sheep were dying in Skull Valley, Utah. Skull Valley is located about 70 miles west of Salt Lake City. It is primarily federally owned desert rangeland. Livestock have grazed continuously in the area since 1890 and thousands of sheep and cattle are pastured there each year. The Department of the Army's Dugway Proving Ground forms the southern and western borders of the valley. The dying sheep had been examined by private and Government veterinarians but the cause of death had not be determined.

When the sheep deaths could not be explained, G. D. Carlyle Thompson, M.D., Director of the Utah State Division of Health, became concerned about the safety of humans living in the affected area and requested Public Health Service, Communicable Disease Center assistance. After consulting with Dr. Mortimer Rothenberg, Scientific Director at Dugway, it was decided to assemble a team with broad capabilities in medicine, veterinary medicine, virology, and epidemiology. In addition to the Utah State Division of Health, representatives from the following agencies participated in the investigation: Utah State Department of Agriculture; Dugway Proving Ground; Edgewood Arsenal; the National Communicable Disease Center, Atlanta, Ga., sent five men; National Animal Disease Laboratory, Ames, Iowa; Poisonous Plant Research Laboratory, Logan, Utah; Department of Ecology and Epizoology, University of Utah; and the Department of Animal Science, University of California, Davis.

Cooperation between all groups engaged in the investigation was excellent.

Although there were no reports of unusual human illness in Skull Valley, three physicians surveyed the 110 inhabitants of the area and could find no illnesses nor complaints that could be associated with the sheep problem. Blood

samples were collected from 43 of the people and tested for cholinesterase suppression. All were within the normal range. A watchful eye was maintained on the human population and several future suspect cases were checked out, but the investigation now concentrated on the sheep.

Autopsies of the sheep and epidemiological data gathered indicated that the cause of death was a toxic agent. Extensive laboratory investigations were performed to determine whether heavy metals or microbiological agents were involved. All cultures of a variety of tissues from affected sheep were negative. Thorough investigations covering insects, parasites, and poisonous plants also failed to provide an acceptable explanation for the sheep deaths.

By the process of elimination, the search narrowed to a toxic chemical agent. Pesticides were suspected since some are used in the area for the treatment of sheep for parasites and for spraying alfalfa fields for weevil. The pesticide possibility was pretty well eliminated by the fact that none had yet been used, due to the earliness of the season. Later, laboratory tests confirmed this conclusion.

Since it was known that the Army had conducted a routine test of a nerve agent just preceding the sheep deaths, Dugway became the focal point of the investigation. A coordinating conference was called for April 1, 1968, at Dugway, with representatives from all the participating agencies being present. Representatives of this coordinating committee met frequently thereafter to review and evaluate findings, with the chairmanship of the committee rotating to the agency where the meeting was held.

The investigation now became the epidemiology of a toxic agent and the value of a community pesticide study in such a situation is obvious. The epidemiological and toxicological capabilities of the program and the facilities of the laboratories are ideally suited for such an investigation.

The task was to identify the presence or absence of a toxic agent in environmental and sheep tissue samples. The task was difficult for two reasons: (1) It was an organophosphate, subject to rapid decomposition and change in the environment; and (2) it is a classified material, subject to security restrictions and as such, was available for standardization on a very limited basis.

Using gas chromatography and a phosphorous sensitive attachment to the flame detector, the Utah Pesticide Laboratory found a significant phosphorous peak, having approximately the same retention time as the agent, in samples of snow and forage from the affected area. This was the first definite lead as to the cause of the sheep deaths. The toxicology laboratory at Atlanta used infrared and mass spectrometry to further identify the agent.

A summary of the work done by the Utah Pesticide Laboratory was given in a report submitted to the coordinating committee. The report gave results of the analyses of samples of snow and water, forage, soil, sheep blood, sheep urine, and human blood. Also, cholinesterase values were determined for sheep and human blood samples. The most significant findings of our laboratory were: (1) The phosphate peak in the forage; (2) normal cholinesterase levels in people; (3) reduced cholinesterase levels in affected sheep blood; and (4) the absence of other pesticides sufficient to be toxic.

In the meantime, Dugway had set up feeding and treatment tests with healthy and affected sheep. Healthy sheep were fed high single dosages of the agent and died rapidly. Other sheep were fed low-level doses of the agent in an attempt to determine the LD_{50} for the agent and to produce symptoms similar to those exhibited by the field-affected sheep. The symptoms did develop and toxic levels were determined, but seemed to be high enough that it was unreasonable to believe that such quantities were present in the affected area.

Kent R. Van Kampen, D.V.M., Ph. D., supervised tests at the USDA Poisonous Plant Research Laboratory at Logan, Utah, in which healthy sheep fed forage from the affected area developed "Skull Valley Disease" symptoms while control-fed sheep did not. Also, healthy sheep put to graze in the affected area developed symptoms in 4 to 6 days indicating the area was still contaminated as of April 4, 1968. Feeding tests with forage collected June 10, 1968, and August 10, 1968, did not result in illness indicating the range had cleared up by then. Dr. Van Kampen has had some of the affected sheep under observation in Logan during the summer and fall. The sheep seem to have recovered to near normal and their reproductive capabilities appear normal.

There were several peculiarities to the incident: (*a*) why were only sheep affected? Why wasn't treatment with atropine effective? (*b*) why weren't the

clinical signs more typical of organic phosphate poisoning; i.e. salavation, pulmonary edema and impaired respiration? Why not humans, cattle, horses, wildlife, or even nursing lambs affected? Some cattle and horses in the area did exhibit depressed cholinesterase, but no clinical signs of the illness. Their forage habits are different. Sheep are probably more susceptible because they have virtually no cholinesterase enzyme in the serum to buffer the effect of the organophosphate.

And, (*c*) how could enough agent possibly get to the affected area to be toxic, and why never before? (Theories: tank failure, thunderstorm.) These, and other questions, were valid enough that it was difficult to definitely establish the cause of death.

What then has been learned from the incident? How is a similar incident to be avoided? If an occasion does arise, how is it to be handled?

Four significant things have happened:

1. In view of all the accumulated evidence, the Army has arranged to pay the farmers for their losses.

2. Attention has been focused on the potential dangers of chemical testing. The safety program at Dugway Proving Ground has been very successful for more than 17 years. During this entire period, just 221 persons were observed for exposure to chemical agents, of whom only 17 were given some treatment. None of the exposures were severe, nor produced any lasting effects. The sheep incident was the first "off-post event" suspected of being connected with Dugway.

3. Several problem areas were identified, for example: Insufficient weather data, insufficient chemical monitoring, the need for the same excellent "community relations" between the military and representatives of the State division of health in regard to chemical testing as had been in effect in biological testing and the need for a safety plan for offpost protection if for any reason the safety of humans, animals, or vegetation is in jeopardy.

With respect to biological agents, Dugway Proving Ground and the State division of health from the beginning of testing biological agents had the closest possible relationship established through a security cleared committee from the staff and from the State board of health that met regularly. This concept of relationship had not previously been extended to chemical agents, although it did exist for several years regarding the burning of beryllium wastes. New testing procedures now indicate the need for the same relationship on chemical testing as for biological.

4. The Secretary of the Army appointed an ad hoc committee to investigate and report on chemical testing safety at Dugway Proving Ground.

Dr. William H. Stewart, Surgeon General of the U.S. Public Health Service, was appointed chairman of the nine-man committee. The committee included two people from Utah—Dr. G. D. Carlyle Thompson, director of the Utah State Division of Health, and Mr. David R. Waldron of the Utah State Department of Agriculture. Also included was Dr. Louis C. LaMotte, Jr., chief of the community pesticide studies.

Dr. Stewart was in Salt Lake City on Friday, December 20, 1968, to give the report of the committee to Gov. Calvin L. Rampton. The committee's report listed 12 recommendations as follows:

1. Test limitations: That testing of nonpersistent agents and small quantities of persistent lethal agents be continued without modification, but testing with larger quantities of persistent lethal agents be subject to restrictions.

2. Toxicity and persistence of compounds to be tested: Additional research should be conducted.

3. Environmental studies covering interactions of the compounds with vegetation, soil, and water should be conducted.

4. Monitoring for the compounds inside and outside the test center. Dugway, the Utah State Division of Health and other agencies should develop a system to detect the presence or absence of chemical agents in the area.

5. Community relations: Dugway should cooperate with the division of health and other State agencies in making them aware of the tests, in exchanging technical information, and in developing and maintaining an emergency plan of action.

6. Meteorology: The climatology for favorable testing should be determined and observed.

7. Medical: Dugway should develop liaison and coordination procedures for

the available medical resources and develop a mass casualty and evacuation plan.

8. Public information: Dugway's ongoing programs should be expanded.

9. Chemical safety committee: The report recommended the establishment of a permanent military-civilian chemical safety committee, knowledgeable in safety procedures involved in the tests. Community leaders, police, and physicians would be represented on the committee and would develop a plan to be put into effect if, for any reason, the safety of the surrounding area was in jeopardy.

10. Program "SAFE": Dugway's program, "SAFE," should be provided with sufficient funds and personnel to implement the entire program subject to review by the permanent chemical safety committee.

11. Land acquisition: A study of the feasibility of the Army obtaining more ground should be completed.

It was reported in the December 27, 1968, issue of "Science" that the Army has adopted all of these recommendations.

The incident was voted Utah's No. 1 news story for the year and still gets considerable attention as these articles show. They describe again the death and burial of the 6,400 sheep, and the Army compensating the ranchers with $364,000. They tell also of the ad hoc committee's recommendations and most recently, that an investigator for the American Association for the Advancement of Science said that chemical tests had proved beyond doubt that nerve gas killed the sheep. So it goes.

Much has been learned from the incident. Hopefully the knowledge will help avoid killing more animals or people. The community pesticide study certainly provides the Utah State Division of Health with a powerful tool to help prevent similar incidents in the future and to take swift, effective action should one occur.

REFERENCES

1. Spencer, David J., M.D. "Investigation of Sheep Deaths—Skull Valley, Utah." A report submitted to the Dugway Coordinating Council, April 29, 1968. Assistant Surgeon General, Director, National Communicable Disease Center, Atlanta, Ga.
2. Van Kampen, Kent R., D.V.M., Ph. D., and associates: "The Skull Valley Incident: An Unusual Organic Phosphate Poisoning of Sheep." A report submitted for publication in September 1968. Research conducted at the USDA Poisonous Plant Research Laboratory, Logan, Utah.
3. Warnick, Stephen L., Ph. D. "Report on the Skull Valley Sheep Incident." Submitted by the Utah State Division of Health, Community Pesticide Study Laboratory, April 10, 1968.
4. Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground, November 1968. Dr. William H. Stewart, Chairman. Surgeon General, U.S. Public Health Service.

Mr. REUSS. I now call on Dr. Barbara Moulton, M.D.

I thank you for your presence and patience, Dr. Moulton.

You have submitted a statement which will be received into the record in full.

Would you now proceed, please, to make your oral presentation?

(Dr. Moulton's prepared statement follows:)

PREPARED STATEMENT OF DR. BARBARA MOULTON, ON BEHALF OF THE NATIONAL BOARD, AMERICAN VETERANS COMMITTEE

Mr. Chairman and members of the subcommittee, I am Dr. Barbara Moulton. I am a physician, with an M.A. degree and additional graduate training in bacteriology in addition to my M.D. degree. I have had clinical experience in infectious diseases and have instructed in that field, but most of my professional work has consisted of regulating the use and testing, and claims for a variety of chemical agents known as drugs. To some extent in my work and to some extent as a dairy farmer I have also acquired considerable knowledge of the chemical and biological contamination of milk and of animals and plants, and of land, water, and air pollution by such chemical agents as fertilizers and pesticides.

My appearance here today is at the request of the National Board of the American Veterans Committee. The national board voted to express opposition to inadequate safety precautions in the atmospheric testing and handling of chemical, biological and radiological weapons. I am speaking for them, and as a private citizen.

When the armed services undertook to develop biologic and chemical weapons, secretly, in such a manner as not to harm anyone in the process, they took on a practically impossible task. They are to be congratulated for having done as well as they have. The difficulties of the job and of the administrative setup are such that the surprising thing is not that they have finally had an accident, but rather that they had none sooner. It is not surprising to me, however, that their first major slipup involved animals outside the testing grounds rather than people inside or that the problem was compounded by their failure to admit responsibility for the damage in time to help prevent further casualties. The technological problems include subjects far removed from the training, experience, or thought processes of the military.

The secrecy under which they have operated has limited the cross-fertilization of ideas that is so essential in complex multidisciplinary problems and has no doubt diminished the caliber of the scientists they have been able to attract to their service. Whatever this subcommittee can do to lessen the secrecy will be to the benefit of all. As many of the scientific problems as can be declassified should be, and there should be as much public participation in the decisions, and as much public knowledge of the actual testing as is compatible with the military goals. There is much more at stake than just good public relations.

The Army has not succeeded in protecting the public interest because there are inherent conflicts of interest throughout the setup. The ad hoc committee report has done an excellent job of pointing out the scientific knowledge which should be available (and obviously was not in the case of VX) before a persistent lethal agent is disseminated in the air. The committee did not discuss why all the information had not been acquired, or how one guarantees better testing in the future. An outside advisory committee meeting once or twice a year and having no operational authority cannot possibly do the job. Merely giving the range safety officer authority to halt tests which he might consider unsafe is not enough, although the fact that he did not possess such authority before the sheep-kill episode is evidence of the relative low priority of safety in the Army's thinking.

These are extremely dangerous substances, with potential for doing a tremendous amount of damage to the lives and property of large numbers of innocent people if any mistakes are made, either in testing them or in disposing of them. Independent review of and control over the methods of their use by an agency dedicated to protection of the public health, rather than to the most efficient methods of killing or incapacitating people, is essential. Except perhaps during major declared war, there is no justification for leaving decisions on these subjects in the sole hands of the Secretary of the Army (or of Defense).

The record should show what I am sure you all know already: that even well-known chemicals can produce unexpected results when used under new conditions; they may combine with other substances to produce new chemicals with very different properties; they produce different results in different species of animals. A substance may be harmless to an adult and extremely dangerous to newborns, or vice versa. Pregnancy can alter susceptibility, as can certain diseases. The administration of certain chemicals to an animal may greatly reduce or greatly potentiate the toxicity of another unrelated chemical to that animal. Food and Drug scientists found one pair of pesticides where the combined toxicity was 1,000 times that of either alone. Certain drugs now in fairly common use block the normal metabolic pathways for handling cheese, and if the patient eats cheese while taking the drug, he will experience serious or occasionally fatal reactions to the cheese. Other drugs make sunlight poisonous. Some drugs are safer in small intermitent doses than in single large doses—others have accumulative effect so that after taking several nonlethal doses another supposedly nonlethal dose can kill. Merely determining the LD_{50} (the single dose that will kill 50 percent of the test animals) is hardly a beginning in modern evaluation of the safety of a drug.

The proposals I have to make deal primarily with operational matters, with changes in administrative responsibilities and procedures, which I believe is really the primary responsibility of your subcommittee. The recommendations of the ad hoc committee do not go far enough, in our opinion, to guarantee to the

public the degree of safety from harm by an agency of the Government to which it is entitled.

We have the following specific recommendations. These should apply not merely to Dugway and the Army, but to all testing anywhere by or for any unit of the Armed Forces, except perhaps during a major declared war. I shall list all the recomendations before discussing any in detail.

1. All open-air testing of lethal or persistent toxic chemicals or of living pathogenic micro-organisms should cease entirely until the other recommendations have been put into effect.

2. Statutory responsibility for determining whether, in fact, testing and use of new or relatively new toxic agents is "consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man, indigeous animals, and domestic livestock" should be vested in the Secretary of Health, Education, and Welfare, or his Assistant Secretary for Health.

3. A permanent safety monitoring staff completely independent of the armed services should be set up. It should be under orders from and paid by the Secretary of Health, Education, and Welfare. The chief of this staff should have operating responsibility for the safety of each test, with authority to stop any test at any time due to changed conditions or new information.

4. All military commanders should receive orders that no such tests should be ordered in the future without a positive confirming order by the chief of the safety monitoring staff.

5. The Chemical Safety Committee recommended by the ad hoc committee should include representatives from the Food and Drug Administration because of their particular knowledge and experience in this field, as well as a rotating group of nongovernmental experts, and should report to the Secretary of Health, Education, and Welfare.

6. Funding of necessary research and monitoring in connection with environmental safety should be removed as much as possible from the Armed Forces and transferred to other agencies as appropriate.

7. A new top-level panel should be set up to reevaluate the entire question of biologic warfare which was not covered by this ad hoc committee's report.

The Secretary of Health, Education, and Welfare is the Federal official responsible for protecting the health of the people. The agencies with most expertise in the field are under his jurisdiction. Harmful effects to indigenous animals and domestic animals are of lesser importance except as they indirectly affect the health of man, so that while the Interior and Agriculture Departments should have voices in the matter, we believe the responsibility should be given to HEW.

Independent experts outside the Government should be consulted frequently—but not always the same experts. When Rachel Carson alerted the public to the hazards of our current use of pesticides, her most violent critics were the independent scientists who had been consulted in the past about pesticide regulation and use by the Government. They defended their own prior judgments by attacking Miss Carson.

Much of the background information on toxicology, persistence, ecology, synergistic actions, etc., is derived from studies done by outside scientists under grants from or contracts with the Army. The point has been made, in matters put into the Congressional Record recently by Senator Nelson, that officials of the State of Utah and scientists at the University of Utah are so conscious of the Army economic contributions to Utah that they no longer function as an independent agent. Certainly the possibility exists that such considerations can affect their statements or actions. To minimize this source of conflict of interest, it would be desirable if most of the funds for such research should be funneled through other departments of the Government, not through the Army. The military-industrial complex is already large enough.

The ad hoc advisory committee recommendations involve a number of value judgments and evaluation of complex scientific questions. They do not explain how these decisions are to be made or by whom, or suggest changes in the system that would prevent exactly the kind of errors that were made last year. For instance:

"The scale of testing must be consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man and representative indigenous animals and domestic livestock." Consistent in whose opinion? Presumably whoever made these decisions through the test last March

was consistent with available toxicological information—although it is quite apparent that the available information was grossly inadequate.

"One artillery round, one rocket, one mine," is not a very precise standard. Who decides how big a gun or rocket or mine is to be used? One rocket could contaminate a very large area.

"No release shall be made at heights greater than 300 feet." How is that to be controlled and by whom. The March 13 test was to have been made at 150 feet.

"No significant fraction of the agent cloud shall be composed of particles smaller than 100 microns in size." Who will be responsible for the quality control of the agent, of measuring the particle sizes, of deciding what is "a significant fraction"? How will particle size be measured? How many sample rockets or mines or the like do you have to release and measure under controlled circumstances in order to determine the range in particle sizes of the agent you are planning to test in the open? How reliable are indoor tests for this purpose? Does the fraction that is significant remain the same regardless of the size of the round, rocket or mine? Obviously not. A very tiny fraction of a very large rocket could result in a very large cloud of particles less than 100 microns in size. Who decides what the total quantity of the agent should be?

Who decides whether the windspeed on a particular day is not too strong, or that no thunderstorms are predicted to occur within 100 miles for 8 hours. Who decides whether past experience has adequately demonstrated sufficient reliability in predicting similar weather conditions?

These are all value judgments. There are at present no hard and fast guidelines. Experience has amply demonstrated that the less strict the guidelines, the more scope there is for individual judgment, the more apt is the decision to be influenced by bias, conscious or unconscious.

In the field of drug testing—and the problems are in many ways similar—it is almost axiomatic that the person or persons who develop a new drug or treatment err on the side of overoptimism. They almost always achieve more favorable results than do subsequent investigators, and report fewer hazards or undesirable side effects. They are the last people who should be trusted to decide whether adequate information is available to reduce to a minimum the probability of harmful effects. It is hardly necessary to remind you that year after year we are told of new hopes for cancer patients, new areas for other diseases, and year after year we find that last year's results were wrong—the first cases were not typical—or the investigators neglected to control some of the variables, or to check some aspect of the drug's pharmacology, and the drug turns out to kill more people than it cures. This has been so consistently true, even when the original investigators were completely honest and well-trained scientists that we now require by law that before human experimentation with drugs begins the results of animal testing and the protocol for human testing be submitted to the Food and Drug Administration for review, and before a new drug may be marketed, there must now be affirmative approval by the Secretary of Health, Education, and Welfare based on substantial evidence of safety and efficacy by all tests deemed reasonably applicable by experts qualified by scientific training and experience to make such decisions.[1]

Is it is not somewhat strange that independent review and approval of test procedures is required by law when chemical agents are to be tested for their possible curative effects in man but not when the same and similar agents are to be used to harm people or are to be scattered in the atmosphere? Is it not also somewhat strange that the agency with specific experience in this field of safety testing and of monitoring quality control procedures was not represented on the interagency ad hoc committee?

It is not safe to assume that every Government agency is just as competent as any other Government agency to make such decisions, or that one set of experts is the same as another. Bias and unintentional blind spots can affect a Government agency as well as an individual, and a pathologist who has made a career of detecting the unexpected hazards of particular drug substances will think of things that will not occur to the pathologist who has spent his professional career making cancer diagnoses for a busy department of surgery.

As an example of governmental blindness, I may cite my experiences with the AEC some dozen years ago when peaceful uses for the atom were of high political priority, the pressure was great to find uses for radioactive substances

[1] See 21 United States Code, sec. 355 (d) and (e).

as drugs. The AEC had a safety monitoring program. They were exceedingly careful about the possible radiological hazards—both to the users and to the patients. They relied, however, on the physicians using these drugs to determine their safety in other respects, and they resisted strongly the idea that these drugs, like all others, should be submitted to the Food and Drug Administration for review prior to general release. It took considerable time and effort on my part and that of a few colleagues at FDA to convince them that radioactive chromium mixed with nonradioactive chromium as a filler might be radiologically safe for repeated diagnostic use and still be quite dangerous to the patient because of the toxicity of the chromium—a point not adequately appreciated by the very excellent internists who were experimenting with the product because this was not their particular field of expertise nor had they been trained to make that kind of evaluation.

Some years ago the Army was working with a potent new chemical, beta propiolactone, for disinfectant purposes. It was proposed for use in hospitals, to sterilize blood, and for various other purposes. The Army, and the Department of Agriculture and the Biological Control Laboratory of the Public Health Service, as well as nongovernmental laboratories, studied it. It was not until a drug use falling under the jurisdiction of the Food and Drug Administration was proposed and the data submitted to the Food and Drug Administration that any concern was expressed over the fact that the substance was carcinogenic—could produce cancer in the individuals who handled it.

On a different level, quality control in the manufacture of drugs is extremely important, and all the better drug manufacturers pride themselves on their quality control programs. They have learned that even on routine manufacturing of batches of a drug that is made regularly in a plant, and for the control of which there are detailed specifications, the number of slipups that occur varies according to the relationship between the control officer and other departments of the company. When the chief of quality control is responsible only to the president, and can overrule the head of any other department, few errors slip by. However, when a vice president for production or sales can overrule an order of the quality control people, errors happen much more frequently. Fewer assays are run, because it is quicker to skip them, or drugs are shipped to the wholesaler before the assays have been completed. Eventually an assay shows up an error after the product has been distributed and a costly and embarrassing recall program may be necessary. This is not because the vice president for sales wants to run risks—but merely because something else is more important to him, and he let this influence his decision to cut corners just this once.

An even more telling example is a study[2] run by one major drug company, in which they asked two clinical investigators to test different drugs for them, in double-blind controlled studies designed to eliminate bias on the part of the investigator which might influence the results. All investigators received the same drugs, but the order in which they were asked to test them varied. When the results were studied, it appeared that the investigators reported more favorable results with the drugs they were asked to study first than with the drugs they were asked to study last. The research director of the company concluded that they assumed the company was most interested in the first drug, and would appreciate a favorable report on it and that this influenced their evaluation of the drug enough to result in perceptible distortion in spite of the elaborate control procedures.

Biological warfare is not mentioned in the ad hoc committee report. Yet it is a matter of public knowledge that the Armed Forces have been studying biologic weapons, and it has been suggested that the presence of antibodies to the VEE virus in indigenous animals in Utah is the result of experiments conducted at Dugway. This might have been the result of deliberate open-air testing or of careless disposal of test material or animals from a laboratory. The suggestion that it might be due to migratory birds does not impress me as a valid argument for ignoring the first two more likely possibilities. We recommend the appointment of a top-level panel of experts in communicable diseases, including a goodly number who have no ties with the Government if it is possible to find any such in this day and age to study the entire question. Such a panel should have authority to demand information and to make on-the-spot inspections of laboratory facilities wherever any work is being conducted by or for the armed

[2] Green, Daniel M., "Journal of New Drugs" 3 : 329, 1963.

services that is even remotely connected with bacteriological warfare, offensive or defensive. The panel should be instructed to address itself to the question of whether the likelihood of success in developing a usable biological weapon is sufficient to justify any further expenditure of time and money on it, in view of the very great risks involved. If the answer to this question is affirmative, they should address themselves secondarily to the question of safety precautions necessary in conducting tests with such material, in laboratories as well as in the field, taking into account hazards to the general population as well as to laboratory personnel.

Milton Leitenberg, in the August–September 1967 issue of Scientist and Citizen, has done an excellent job of summarizing the extremely grave problems posed by this particular kind of weapon. I shall not repeat it, but merely add my own conviction that the threat to all mankind from a tactically effective biologic weapon, if we ever develop one, would be as great if not greater, than the threat of the hydrogen bomb. All experimental work with pathogenic micro-organisms is dangerous. Laboratory infections are much too common. The potential positive gains should be quite substantial to justify even these risks. The great Australian immunologist, Sir MacFarlane Burnett,[3] has warned that even studying the molecular structure of viruses is a major threat to mankind because of the likelihood of eventual careless handling of a mutant strain which will prove deadly and which will get out of hand. The problems that can occur when any lethal agent is field tested multiply rapidly when the agent itself can multiply and adapt. It is my own conviction that we do not now have, and probably will not have for several generations to come, sufficient knowledge to enable us to develop an effective biologic weapon which can be used with reasonable safety to the user.

STATEMENT OF DR. BARBARA MOULTON, ON BEHALF OF THE NATIONAL BOARD, AMERICAN VETERANS COMMITTEE, INC.

Dr. MOULTON. Thank you.

I feel rather anticlimactic after all the brass we have had this morning.

I am a physician. I have had graduate training in bacteriology in addition to my M.D. degree, and I have had clinical experience with infectious diseases, but most of my professional career has been involved with the subject of testing of a particular brand of chemicals, drugs; testing; namely, evaluating tests for, and worrying about, claims for the safety and efficacy of drugs, which are chemicals.

I have also had some interest both professionally and in my avocation as a dairy farmer in the subject of chemical and biological contamination of milk and animals and plants and land and water and air pollution, with other chemicals such as fertilizers and pesticides.

I am testifying today on behalf of the National Board of the American Veterans Committee, and as a private citizen.

When the armed services took on the task of developing highly toxic biological and chemical weapons secretly and in a manner so as not to do any harm to the innocent bystander, they took on an almost impossible job. They are to be congratulated for having done as well as they have.

The difficulties of the job and of the administrative setup under which they are operating are such that the surprising thing to me is not that they finally had a major accident but that it took so long before they had at least a reported serious accident.

I understand they have had some problems before. My husband tells me about having heard from the Army of problems with military

[3] "Men or Molecules? A Tilt at Molecular Biology." Lancet 1 : 37, 1966.

personnel getting burned from mustard gas at Edgewood, I believe it was, some 15 or 20 years after it had been tested in a particular spot where they were sitting.

But secrecy is one of the major problems. This limits the cross-fertilization of ideas that are so essential when you are involved with complex multidisciplinary problems, and it has no doubt diminished the caliber of the scientists they have been able to attract to their service. Whatever you can do to lessen the secrecy will be to the benefit of everybody concerned. And it would be our hope that you could succeed in getting as many of the issues, as many of the problems involved, declassified as possible.

I was delighted this morning when you asked to be notified about field tests in the future, but I cannot see any reason why the public should not know: This week we are going to test a live, potent nerve gas, some time this week. And if anything happens to your animals in the next week, bear this in mind. Or if you have any unusual symptoms within the next week, bear this in mind. We are this week field testing something new. Or we are tomorrow going to do so.

I do not see why that has to be classified.

I don't see why the toxicology on this all has to be classified. It is not in foreign countries, according to previous testimony that you have had.

The Army has not succeeded in protecting the public interest entirely, and in my opinion this is because there are inherent conflicts of interest throughout the setup. The ad hoc committee report has done an excellent job of pointing out the scientific knowledge which should be available and which obviously was not in the case of VX before a persistent lethal agent is disseminated in the air.

The committee did not discuss why all the information had not been acquired, nor did they discuss adequately how one guarantees better testing in the future. There has been nothing said about what we are going to do to prevent further malfunctions in the tanks that release toxic materials. As far as I can see there is still a veil of secrecy over that.

An outside advisory committee meeting once or twice a year and having no operational authority cannot possibly in my opinion do the job. Merely giving the range safety officer authority to halt tests which he might consider unsafe is not enough, although the fact that he did not possess such authority before the sheep-kill episode is evidence of the relatively low priority of safety in the Army's thinking.

On the subject of an outside advisory committee finding out all that is wrong with the testing procedure, some years ago I was taken as a training procedure by one of the most experienced food and drug inspectors to see what is involved in inspecting a drug company to be sure that their manufacturing quality control is all right. We spent 2 days in one plant, Abbott Laboratories, going over the manufacture of one particular chemical, one particular antibiotic.

That was the end of my assignment but the inspector had not finished. He told me that at that time, if they were doing a really serious inspection of Abbott, they would take a couple of weeks, maybe more. I understand that now the FDA inspectors are practically in residence at some of the major companies. Even a trained inspector cannot find all the pitfalls in a short time.

From another point of view, as a dairy farmer, I have seen that when something goes wrong, an inspector cannot come in and find out in a short time what has gone wrong. If you are going to rely on outside advice to be sure that there is adequate quality control of all the procedures all the way along, it takes considerably more time than one panel of top-level experts coming in once or twice a year for a meeting can possibly give.

There should be such a panel but they should be in an advisory capacity and there needs to be much more than that.

These are extremely dangerous substances that we are playing with, having potential for doing a tremendous amount of harm. Independent review of and control over the methods of their testing by an agency dedicated to protection of the public health rather than to the most efficient methods of killing or incapacitating people is essential.

Except perhaps during a major declared war, there is no justification for leaving decisions on these subjects in the sole hands of the Secretary of the Army or the Secretary of Defense.

The record should show what I am sure you all know already, that even well-known chemicals can produce unexpected results when used under new conditions. They may combine with other substances to produce new chemicals with very different properties. They produce different results in different species of animals, and in different subspecies.

If you are worrying about human toxicology I found myself wondering as I listened, do we know whether the reaction of the Indians and of the Basque sheepherders and of the Mexicans that no doubt are in that area is the same as that of the ordinary Caucasian?

In South Africa they had to take terrific precautions in using ordinary barbiturate anesthetic agents because a high percentage of the population has a recessive gene that makes them very much more susceptible than average to that particular group of drugs although it does not harm them noticeably under normal circumstances.

American Indians and Asiatics frequently react differently to some drugs than do Caucasians. There are whole drugs that create special problems for people from the Mediterranean area and from Southeast Asia, not because of race, but because of generations of exposure to malaria.

A substance may be relatively harmless to an adult and extremely dangerous to newborns. The whole question of testing for safety of these substances is exceedingly complex, and we still don't know anywhere near enough about it. But merely finding out what acute dose will kill 50 percent of a specie of animal or any number of species of animals is nowhere near enough.

One of the most important factors is the potentiation of one drug by another. That has been touched on before. Thumbing through my reports last night to remind myself of some of the examples, I encountered one that might interest the nonprofessional, an episode of toxicity attributed by the sufferers to beer, and they discovered that it was because they had eaten a particular specie of mushroom which you can eat with beer perfectly safely, but if you eat it 24 hours before the beer, the beer makes you sick.

Mr. REUSS. There is nothing wrong with the beer?

Dr. MOULTON. Nothing wrong with the beer. It just reacts with the breakdown products of the mushrooms.

There was another one where the reverse was true, that if you had alcohol 24 hours before carbon tetrachloride, it greatly increased the toxicity of the carbon tetrachloride, but if you take them at the same time, there is no increase in toxicity.

I have mentioned in my written report the problem of the drugs that make cheese a dangerous substance. It's not just cheese; the same phenomenon has been reported with broad beans and Bovril and various other products containing yeast, and some of the reactions have been fatal.

So that the complex interactions are exceedingly difficult to predict. And they are part of the consideration that must be given to whether field testing is safe.

In connection with specific recommendations, which apply not merely to Dugway and not merely to the Army but to all testing anywhere, by or for any unit of the Armed Forces, except perhaps during a major declared war, I think that all open-air testing of lethal or persistent toxic chemicals or of living pathogenic micro-organisms should cease entirely until the other recommendations that I am going to make are put into effect; not just persistent lethal, but any persistent toxic agent.

Statutory responsibility for determining whether in fact testing and use of new or relatively new toxic agents is "consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man, indigenous animals and domestic livestock," should be vested in the Secretary of Health, Education, and Welfare, or his Assistant Secretary for Health.

A permanent safety monitoring staff completely independent of the armed services should be set up. It should be under orders from, and paid by, the Secretary of Health, Education, and Welfare. This is not instead of, but in addition to, the Army's own internal safety system. The chief of this staff should have operating responsibility for the safety of each test, with authority to stop any test at any time due to changed conditions or new information, or for any other reasons of safety.

All military commanders should receive orders that they should not schedule and order tests without a positive confirming order by the chief of the safety monitoring staff.

The Chemical Safety Committee recommended by the ad hoc committee should include representatives from the Food and Drug Administration because of their particular knowledge and experience in this field, as well as a rotating group of nongovernmental experts, and should report to the Secretary of Health, Education, and Welfare.

Funding of necessary research and monitoring in connection with environmental safety should be removed as much as possible from the Armed Forces and transferred to other agencies as appropriate.

A new top-level panel should be set up to reevaluate the entire question of biologic warfare which was not covered by this ad hoc committee's report.

The Secretary of Health, Education, and Welfare is the Federal official responsible for protecting the health of the people. The agencies

with most expertise in the field are under his jurisdiction. Not that any Federal agency is always perfect, not that HEW does not make mistakes; but if you have both the Army and HEW sharing responsibility, in a sense they have different constituents among the people, they have different goals, they have different points of view, which is a tremendous safety factor.

Independent experts outside the Government should be consulted frequently—but not always the same experts. And not always the same type of expert. I am sure the gentleman from Du Pont will be a tremendous addition in terms of increasing safety in the handling of chemicals, not letting them escape, not letting them contaminate the environment as they handle them in their ordinary use of them. But in terms of presenting a different point of view on relative importance of safety versus other factors, he hardly represents the general public as opposed to the military mind.

But experts can fall into the trap of advising the Government so often that they develop the Government's point of view and are no longer truly independent agents. When Rachel Carson alerted the public to the hazards of our current use of pesticides, her most violent critics were specifically the particular independent scientists who had been consulted in the past about pesticide regulation and use by the Government. They defended their own prior judgments by attacking Miss Carson. They were apparently on the defensive and rushed to assure the world that there was nothing to her charges.

Much of the background information on toxicology, persistence, et cetera, is derived from studies done by outside scientists under grants from, or contracts with, the Army. This also raises a conflict of interest question. It has been pointed out that a large percentage of the nonagricultural personal income of the people of Utah is derived from the Army. Were many of these research grants to pass through HEW or Interior or Agriculture, it would dilute the specific influence of the Army on the thinking of the area, and probably lessen the potential conflict of interest.

The military-industrial complex is already quite large enough.

The ad hoc advisory committee recommendations involve a number of value judgments and evaluation of complex scientific questions. They do not explain how these decisions are to be made and by whom, nor suggest changes in the system that would prevent exactly the kind of errors that were made last year. For instance:

"The scale of testing must be consistent with available toxicological information." But consistent in whose opinion? Presumably whoever made those decisions last March felt that the tests then were consistent. And yet it is quite apparent that they were not. The specification is that they may continue firing one artillery round, one rocket, one mine. This is not very precise. Who decides how big a rocket or mine or round?

I understand that the Army has one rocket that weighs over 5,000 pounds. That would have a payload of several thousand pounds, I would think. And several thousand pounds of lethal gas would hardly stay on the grid. Obviously they are not using rockets of that size. But there is nothing in anything we have heard so far that limits the amount of total payload in their one rocket to a safe amount.

"No release shall be made at heights greater than 300 feet." But we have no assurance as to how that is to be conrtolled, or by whom. And nothing has been said that indicates that any different people will be worrying about the problem of controlling it. The March 13 test was to have been made at 150 feet, but some material was released at 1,500 feet.

"No significant fraction of the agent cloud shall be composed of particles smaller than 100 microns in size." But who will be responsible for the quality control of the agent, of measuring the particle size, or deciding what is a significant fraction? How will particle size be measured? How many sample rockets or mines do you have to release and measure under controlled circumstances in order to determine the range of particle sizes of the agent you are planning to test in the open? Dr. Stewart implied that there are always going to be some very small particles; which certainly jibes with my own idea on the subject.

If your original payload is large the number of particles that are less than 100 microns in size and, therefore, that will go beyond Route 40, is considerably greater than if you have a small test mine or test rocket. Without controlling the size of the agent used, you have not really solved the problem.

These are all value judgments. There are at present no hard-and-fast guidelines; at least not that the public is aware of. Experience has amply demonstrated that the less strict the guidelines, the more scope for individual judgment, the more apt is the decision to be influenced by bias, conscious or unconscious.

In the field of drug testing—and the problems are in many ways similar—it is almost axiomatic that the person or persons who develop a new drug or treatment err on the side of overoptimism. They almost always achieve more favorable results than do subsequent investigators, and report fewer hazards or undesirable side effects. They are the last people who should be trusted to decide whether adequate information on safety is available.

It is hardly necessary to remind you that year after year we are told of new hopes for cancer patients, new cures for other diseases. And year after year we find that last year's results were wrong. The first cases were not typical, or the investigators neglected to control some of the variables, or to check some aspect of the drug's pharmacology; and we end up finding that the drug is killing more people than it is curing. This has been so consistently true, even when the original investigators were completely honest and well-trained scientists, that we now require by law that before human experimentation with drugs begins the results of animal testing and the protocol for human testing be submitted to the Food and Drug Administration for review. And before a new drug may be marketed there must be affirmative approval by the Secretary of Health, Education, and Welfare based on substantial evidence of safety and efficacy by all tests deemed reasonably applicable by experts qualified by scientific training and experience to make such decisions.

That's a paraphrase from the Federal Food, Drug, and Cosmetic Act.

Is it not somewhat strange that independent review and approval of test procedures is required by law when chemical agents are to be

tested for their possible curative effects in man, but not when the same or similar agents are to be used to harm people or are to be scattered in the atmosphere?

Is it not also somewhat strange that the agency with specific experience in this field of safety testing and of monitoring quality control procedures was not represented on the interagency ad hoc committee?

It is not safe to assume that every Government agency is just as competent as any other Government agency to make such decisions, or that one set of experts is the same as another. Bias and unintentional blind spots can affect a Government agency as well as an individual, and a pathologist who has made a career of detecting the unexpected hazards of particular drug substances will think of things that will not occur to the pathologist who has spent his professional career making cancer diagnoses for a busy department of surgery.

As an example of governmental blindness I cite my experiences with the AEC some dozen years ago when peaceful uses for the atom were of high political priority, and the pressure was great to find uses for radioactive substances as drugs. The AEC had a safety monitoring program. They were exceedingly careful about the possible radiological hazards both to the users and to the patients. They relied, however, on the physicians using these drugs to determine their safety in other respects, and they resisted strongly the idea that these drugs, like all others, should be submitted to the Food and Drug Administration for review prior to general release. It took considerable time and effort on my part and that of a few colleagues at FDA to convince them that radioactive chromium mixed with nonradioactive chromium as a filler might be radiologically safe for repeated diagnostic use and still be quite dangerous to the patient because of the toxicity of the chromium itself—a point not adequately appreciated by the very excellent internists who were experimenting with the product, because this was not their particular field of expertise nor had they been trained to make that kind of evaluation.

Some years ago the Army was working with a potent new chemical, beta propiolactone, for disinfectant purposes. It was proposed for use in hospitals, to sterilize blood, and for various other purposes. The Army and the Department of Agriculture and the Biological Control Laboratory of the U.S. Public Health Service, as well as nongovernmental laboratories, studied it. It was not until a drug use falling under the jurisdiction of the Food and Drug Aministration was proposed and the data submitted to the Food and Drug Administration that any concern was expressed over the fact that the substance was carcinogenic—could produce cancer in the individuals who handled it.

I have already talked about quality control, and I will skip it. It's in the written record. But it's a very important subject, and bias in the person who makes the decision can alter radically the results of your control program.

The subject of biological warfare is not mentioned in the ad hoc committee report. Yet it is a matter of public knowledge that the Armed Forces have been studying biologic weapons, and it has been suggested that the presence of antibodies to the Venezuelan equine encephalonyelitis (VEE) virus in indigenous animals in Utah is the

result of experiments conducted at Dugway. This might have been the result of deliberate open-air testing, or of careless disposal of test material or of animals from a laboratory.

The suggestion that it might be due to migratory birds does not impress me as a valid argument for ignoring the first two more likely possibilities.

We recommend the appointment of a top level panel of experts, including a goodly number who have no ties with the Government, if it is possible to find any such in this day and age, to study the entire question. Such a panel should have authority to demand information and to make on-the-spot inspections of laboratory facilities wherever any work is being conducted by or for the Armed Services that is even *remotely* connected with bacteriological warfare, offensive or defensive.

The panel should be instructed to address itself to the question of whether the likelihood of success in developing a usable biological weapon is sufficient to justify any further expenditure of time and money on it, in view of the very great risks involved. If the answer to this question is affirmative, they should address themselves secondarily to the question of safety precautions. This is not what the present ad hoc committee did.

I think there should be a panel of outside people who address themselves to the question of whether we should even conduct *any* tests on biological warfare. It is my own personal conviction that we are a very long way, as a race, from having sufficient scientific knowledge and know-how to safely deal with bacteriological warfare in terms of producing a usable weapon that won't backfire seriously on the rest of society, not just on the enemy.

I cited in my prepared statement an article by Sir MacFarland Burnet that is relevant to this point, that I would like to put into the record.

(Subcommittee Note.—The article referred to, "Men or Molecules? A Tilt at Molecular Biology"—Lancet 1:37, 1966—is in the subcommittee files.)

I think we need to have some evaluation also of whether the purpose, for which the testing of lethal chemical weapons is done, is sufficient to justify the risk. In medicine, in the last few years, particularly since the thalidomide episode, we have had a great deal of talk about the need for informed consent of the patient before anybody experiments on him. And the same principle applies here.

We have a situation where the Government is using the public as guinea pigs. They are using the citizens of Utah as inadvertent, unknowing guinea pigs without their informed consent as to the relative merits of the program and whether it justifies the risks that these same citizens are being subjected to.

I am not sufficiently a military expert to know whether it is that important to be precisely sure of how well VX, as compared to a stimulant, stays on target; but I find it hard to believe that precise information on this point is such as to justify running any risks to the nearby citizens. And I think they ought to have the right to affect this decision to some degree, knowing what the risks are.

I am not impressed by the idea that extending the size of the proving ground will help much. They would probably increase the size of

the tests. Nature abhors a vacuum. Human activity follows the same law, and we would shortly have the same problem again, with a different boundary.

If you have any questions I would be happy to try to answer them.

Mr. REUSS. Thank you very much, Dr. Moulton.

Mr. Gude?

Mr. GUDE. No questions.

Mr. REUSS. We appreciate very much your excellent presentation this afternoon.

(Subsequently, Dr. Moulton submitted the following statement for inclusion in the hearing record:)

One of the Army spokesmen stated again at the hearing that the March 13 test of VX did not endanger human beings. This is no more true than their earlier opinion that no domestic animals or wildlife were endangered. It is apparently true that there is no evidence that human beings were in fact harmed, but they might well have been.

Suppose a troop of Boy Scouts from Salt Lake City had been out camping in those mountains that week learning to rough it; suppose one of those boys had also been taking one of the phenothiazine tranquilizers, which are known to increase the toxic effect of and decrease the chances of survival from exposure to this particular group of poisons; suppose the amount of VX released at high altitude had been a little bit greater and the precipitation of snow concentrated in a smaller area; and suppose the troop had used the contaminated snow for making soup and hot chocolate or coffee. Under such circumstances the fatalities might not have been limited to sheep and wild animals. None of these suppositions are particularly farfetched. Camping and hunting in those mountains is apparently fairly common; phenothiazine tranquilizers are very widely prescribed; children are usually more susceptible to most types of poisoning than adults; a cloud may discharge all its moisture in a very limited area.

Mr. REUSS. There being no further witnesses, the Subcommittee on Conservation and Natural Resources will stand in adjournment.

(Whereupon, at 3:35 p.m., the subcommittee was adjourned.)

APPENDIXES

Appendix 1.—Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground, Department of the Army, Washington, D.C., November 1968

I. Summary and Recommendations

A comprehensive review was made of the procedures, talents, monitoring equipment, facilities, and safety regulations used by the Army to support chemical test activities at Dugway Proving Ground. Problem areas in the subjects of ecology, toxicology, chemistry, fate of chemicals in the environment, meteorology, community relations and public information were discussed in great detail. It is the judgment of the committee that current procedures and practices are sound and adequate for field testing certain classes of chemical agents and munitions. However, additional steps must be taken to insure the adequacy of these procedures and practices when field testing other specific classes of chemical agents and munitions.

A. Test limitations

1. *Discussion.*—In terms of desirable safety restraints, chemical test programs can be identified under one of five headings. These headings are riot control agents, incapacitating agents, nonpersistent lethal agents, persistent lethal agents, and new agents. Under the latter heading (new agents) fall those future test programs in which the newness of the agent may require special safety restraints and therefore will not be addressed by this committee. Current operating practices and restraints are adequate to support all tests currently programed under the first three headings. The basic principle underlying the safe conduct of any chemical test is the eventual depletion and dilution of the toxic material by natural processes by the downwind travel of the cloud over controlled areas. At Dugway, the largest controlled area is the salt flats area to the northwest of the major test grids (see app. A). Therefore, large scale testing of persistent lethal agents should be designed and executed in a manner which insures the depletion and dilution of the cloud within the controlled salt flats area. This restriction should remain until studies of vegetation, soils, and wildlife and an increased Dugway meteorological capability indicate this restriction can be modified safely.

2. *Recommendations.*—The committee recommends that—

(*a*) Testing of riot control, incapacitating and nonpersistent lethal agents and munitions be resumed without modification of current practices and safety procedures. The scale of testing must be consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man, representative indigenous animals and domestic livestock.

(*b*) Testing of persistent lethal agents and munitions in quantities of agent not to exceed the equivalent of one artillery round, rocket, or mine be resumed without modification of current practices and safety procedures. The scale of testing must be consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man and representative indigenous animals and domestic livestock.

(*c*) Plans of test for programs involving persistent lethal agents in quantities greater than those specified in 2(*b*), above, will specify restraints in scope of testing and meteorological restrictions needed to comply with the following criteria: (These restraints should remain in effect until reviewed by a permanent chemical safety committee recommended elsewhere in this report.)

31-509—69——13

(1) The combination of windspeed, release height, and particle size shall be controlled to provide maximum depletion of the cloud within the initial downwind travel period. No release shall be made at heights greater than 300 feet; also no significant fraction of the agent cloud shall be composed of particles smaller than 100 microns in size. Positive control of agent dissemination will be maintained by automatic flow devices, radar and radio control, by establishment of limitations on total quantity of agent dispersed and other available means when high performance aircraft are used for dispensing toxic chemical agents having properties equivalent to those of the nerve agent VX.

(2) The cloud shall remain in a sector between north and northwest of the test area and not cross U.S. Highway 40 for at least 3 hours.

(3) The windspeed at standard anemometer altitudes (10 to 30 feet) shall be as low as possible but no stronger than 15 miles per hour.

(4) No thunderstorms shall be present within 100 miles of the test site at release time nor predicted to occur within 100 miles of the cloud trajectory for at least 8 hours from actual release time.

(5) Confidence in the weather forecast shall be high; there must be past experience demonstrating the reliability of predictions from similar weather situations.

B. Toxicological research

1. *Discussion.*—Knowledge of the toxicity of any compound to be released into the environment during tests at Dugway Proving Ground is an important part of the pretest evaluation of the chemical. The safety of the people and animals living not only in the immediate area of the test but also within several tens of miles of the point of release of the compound must be considered along with the aggressive characteristics of the chemical. Much of this information is already known. However, to insure that all essential knowledge gaps are filled, immediate steps should be taken to obtain necessary toxicological information on all chemical agents tested.

2. *Recommendations.*—The committee recommends that—

(*a*) Determination or estimation be made of the toxic and lethal activities of single and repeated doses of the chemical by intravenous, intramuscular, subcutaneous, oral, inhalation, and cutaneous injection or application, on humans or animals, including laboratory speices, economically important species in the vicinity of Dugway Proving Ground (DPG), and representative wild species, living on or near DPG, of both sexes and representative age brackets, and on pregnant females.

(*b*) Toxicity and persistence of residues of the compound on test sites and other areas of Dugway Proving Ground be determined.

(*c*) Determination or estimation be made of the toxic and lethal activities of repeated oral and cutaneous doses during the period of persistence, of the chemical and its residues, on humans or animals of both sexes and of all ages, and on pregnant females.

(*d*) Estimation be made of the additional insult due to the chemical in foraging animals that have partaken already of known poisonous forage plants, halogeton for example, indigenous to the area of the testing facility.

C. Environmental studies

1. *Discussion.*—Knowledge of the effect of indigenous vegetation, soil, and water at the proving ground and in adjacent areas on the behavior and fate of chemical agents is an integral part of the safety requirements for current types of testing at Dugway and will be critically important for future testing with high-performance weapons systems. Effort should be expanded to obtain necessary information on the fate in the environment of all chemicals tested.

2. *Recommendations.*—The committee recommends that:

(*a*) Determination be made of the presence and persistence of toxic residues of chemicals upon indigenous vegetation and of their absorption from the soil by indigenous plants; whether the plant decreases or increases the toxicity of the chemical after its absorption into the plant. Absorption, uptake, and metabolic transformation by the plant must be studied for each individual chemical agent.

(*b*) Determination be made of the presence and persistence of the compound in soil and in water supplies, including snow, at all seasons of the year in the neighborhood of the testing site.

D. Monitoring for chemical agents

1. *Discussion.*—Dugway Proving Ground has supported a sizable ecology and epidemiology program over the past 17 years covering the proving ground and surrounding areas. This program has been designed particularly to relate to the biological testing that has been conducted at the proving ground. As a result of the sheep deaths, Dugway should not only continue this ecology and epidemiology effort but should establish an adequate monitoring program designed to detect the entry of chemicals into the natural environment outside the boundary of DPG and the actions of these chemicals on the natural animal populations resident there. The committee believes that there are two interrelated monitoring systems required: one based on the immediate detection of a substance and the second based on ecological effects.

2. *Recommendation.*—The committee recommends that:

Deseret Test Center develop monitoring systems both within and outside the boundaries of Dugway Proving Ground for baseline data collection and to detect the presence of or verify the absence of chemical agents by both immediate responsive methods and by ecological monitoring. The system should be developed in coordination with the Utah State Department of Health and other appropriate Utah State and Federal agencies.

E. Community relations

1. *Discussion.*—(*a*) Community relations is an essential part of any safety program of the Deseret Test Center. Even though all precautions are taken during testing of chemical agents, safety planning must account for the remotest possibility of exposure to humans, animals, and vegetation offpost. The surest way to have solid community relations as an essential part of the safety program is to seek and obtain participation in the development and maintenance of any safety plan involving offpost protection. This should include knowledge by some community leaders, such as State officials, of the safety procedures involved in the tests themselves; the remote possibility of offpost contamination; and the offpost precautions taken; that is, monitoring to detect contamination. It should also include the development of a plan of action with appropriate community leaders, police, physicians, and so forth, in the surrounding area if for any reason the safety of human beings, animals, or vegetation has been jeopardized.

(*b*) Without community involvement in the plan for offpost safety at the Deseret Test Center, Utah State officials, community leaders, and the public must rely on assurances of the U.S. Army that all precautions have been taken and that the testing is completely safe. Experience has shown in other situations that assurances given by the testing group reinforced by assurances of knowledgeable State officials and community leaders are more readily acceptable by the public at large.

(*c*) There are three essential parts to good community relations in the offpost safety plan of Deseret Test Center. First, there is the need for knowledge, both general and technical, on the part of certain officials of the activities of the test center, the safety procedures, and the offpost safety plan that has been developed. Second, there is the need for joint offpost monitoring by both Deseret Test Center and Utah State as part of the safety operation. And finally, there is need for the development of a meaningful plan of action in the State in the unlikely event of offpost contamination with chemical agents.

2. *Recommendations.*—The committee recommends that—

(*a*) Deseret Test Center shall take the initiative to inform certain key Utah State officials of the general nature of the activities of the test center and the relationship of testing to the community.

(*b*) Deseret Test Center shall establish a mechanism with the Utah State Department of Health, Utah Department of Agriculture, and other appropriate Utah State agencies for the exchange of technical information on chemical test planning as it relates to offpost monitoring and safety.

(*c*) Deseret Test Center in collaboration with Utah State officials shall work with the communities surrounding the test site to develop and maintain a standby emergency plan of action. This will include an alerting system, a command point, and levels of action to be taken.

(*d*) Deseret Test Center shall establish a procedure providing for liaison and coordination with designated civilian entities and agencies during test planning and testing of chemical agents which have any possibility of offsite dissemination.

F. Meteorology

1. *Discussion.*—In the conduct of chemical tests, the prediction of transport, dilution, and deposition has always been a critical element. The characterization of cloud behavior in the initial 1 or 2 miles of downwind travel has become a routine procedure. Because of the additional complexity of the problem, progress has been slow despite the existence of a continuing program to extend predictive capability to greater downwind distances.

2. *Recommendations.*—The committee recommends that—

(*a*) The prediction capability for the transport, dilution, settling, and deposition (including thunderstorm scavenging) of chemical agents to distances of several tens of miles be determined and improved.

(*b*) Post-test estimates of cloud transport, dilution, and deposition for all significant tests be routinely reconstructed.

(*c*) Experiments to evaluate the resuspension due to wind action of deposited chemical agents be conducted.

(*d*) A climatology of favorable testing period based on various weather restrictions be prepared.

G. Medical

1. *Discussion.*—(*a*) Review of available test planning directives and facilities demonstrate their exceptional adequacy for onsite safety and medical responsibilities and procedures. There is only very general direction for "effecting necessary coordination with all agencies involved" which would, presumably, include State and Federal health and agricultural agencies vitally interested in measures to protect offpost civilians, livestock, and grazing areas should an accident occur. These general directions should be specific as to when and with whom coordination should be made. Coordination, liaison and planning should be accomplished with specified outside organizational entities such as State public health director, county health officers, regional U.S. Department of Agriculture representatives and U.S. Department of the Interior, Bureau of Land Management, regional representatives.

(*b*) Safety consciousness of medical, professional and auxiliary personnel involved in the planning or execution of test missions is evaluated as very good based on knowledge of training, equipment, and test procedures. In the area of coordination, knowledge and planning for mass casualty disasters involving military or civilian populations not directly or indirectly concerned with chemical testing, there is either a lack of complete orientation of medical personnel or incomplete planning for the rare, unexpected accidental exposure of groups of personnel not involved with testing who live on Dugway Proving Ground or in areas surrounding the test installations.

2. *Recommendations.*—The committee recommends that—

(*a*) Deseret Test Center and U.S. Army Hospital, Dugway Proving Ground shall develop a mass casualty plan to include specific care and evacuation procedures for patients exposed to chemical agents.

(*b*) Deseret Test Center shall develop liaison and coordination procedures with outside medical resources to insure a feasible medical evacuation.

(*c*) Deseret Test Center shall extend medical professional liaison to provide information and medical assistance to the civilian medical community.

(*d*) Deseret Test Center shall conduct at least annual exercises to test mass casualty and medical evacuation procedures.

H. Public information

1. *Discussion.*—An aggressive public information program designed to provide maximum information, within security restraints, to local State inhabitants concerning the mission, facilities and testing activites of the Deseret Test Center is considered vital to the molding of good community relations.

2. *Recommendation.*—The committee recommends that: Deseret Test Center expand its public information programs for appropriate Utah State and Federal officials and for the public.

I. Chemical Safety Committee

1. *Discussion.*—(*a*) The Ad Hoc Committee is temporary in nature and can conduct only a one-time review of the past and current adequacy of safety measures at Dugway Proving Ground. Since testing is a continuous mission and safety a constant part of this mission, the committee believes there is a high priority requirement to establish a permanent interagency technical safety

committee advisory to the commanding general, Deseret Test Center. This committee once established should meet at least annually or on call as required by the commanding general, Deseret Test Center.

(*b*) The purpose of the committee would be—

(1) To review and analyze Deseret Test Center programs in metorology, test technology, chemistry, ecology, plant and animal physiology, toxicology and safety procedures.

(2) To examine the immediate and residual hazards to man, wildlife, domestic animals, and plants on and off test sites as related to test activities

(3) To analyze and identify knowledge gaps in the Deseret Test Center test safety programs.

(4) To advise and recommend to the commanding general, Deseret Test Center, actions, safety criteria and procedures required for the safe transport, safe storage and disposal of chemical test activities.

(*c*) Membership in the committee should bring to the commanding general high-level scientific talent found in branches of the appropriate scientific disciplines such as chemistry, ecology, meteorology, toxicology, soil science, plant and animal physiology, medicine and public health. Appropriate representation from the State of Utah should be included in the committee.

2. *Recommendation.*—The committee recommends that: A permanent Chemical Safety Committee advisory to the commanding general, Deseret Test Center be established. Representation from the State of Utah should be included.

J. Program SAFE

1. *Discussion.*—The committee was briefed in detail on program SAFE. This program represents an aggressive, dynamic, comprehensive safety program that was developed by Deseret Test Center to assure safe testing in the future at the proving ground. Many of the recommendations of this committee are contained in program SAFE. The committee urges the Department of Army to provide maximum support of this effort.

2. *Recommendations.*—The committee recommends that—

a. The recommendations of this committee be included in program SAFE.

b. The commanding general, Deseret Test Center be provided with sufficient funds and personnel to complete and implement the program.

c. Program SAFE be reviewed by the permanent Chemical Safety Committee as required.

K. Land acquisition

1. *Discussion.*—The recommendations of this report as to safety were based on the present size of Dugway Proving Ground and the Wendover Bombing Range. The question of acquiring management rights for additional areas was discussed. Information was too scanty to arrive at any judgment of the effects of acquiring management rights to additional land areas on the recommendations of this committee.

2. *Recommendation.*—The committee recommends that the Department of Army complete its study as to the feasibility of obtaining management rights for the additional land areas adjacent to the Dugway Proving Ground.

II. INTRODUCTION

As part of the Army's response to the death of sheep in the vicinity of Dugway Proving Ground in March of this year, the Secretary of the Army established an ad hoc advisory committee for review of testing safety at Dugway Proving Ground. The committee, chaired by the Surgeon General of the U.S. Public Health Service, included representatives from the U.S. Departments of Agriculture, Commerce, Interior, and Defense; officials from the Utah State Departments of Health and Agriculture, and a scientist from the Albany Medical College of Union University. (Committee members and consultants are listed in sec. VI, p. 38.)

The committee was requested to review the procedures, talents, monitoring equipment, facilities, and safety regulations used by Dugway Proving Ground in connection with chemical tests. The purpose of the review was to determine whether or not safety measures are adequate to insure that chemical tests at Dugway Proving Ground do not constitute a hazard to humans, animals, and plants outside the boundaries of the proving ground or in the housing and administrative areas of the proving ground. The committee was requested to make such recommendations as it deemed necessary to achieve this goal.

The committee visited Edgewood Arsenal, Md., on June 25, 1968, and received a comprehensive briefing on the physical and medical aspects of chemical agents of interest that are currently being field tested at Dugway Proving Ground or planned for test in the foreseeable future. Methods of agent dissemination and defensive aspects of chemical testing were discussed. Dugway Proving Ground, Utah, and Deseret Test Center, Fort Douglas, Utah, were visited during the period July 8 through 10, 1968, at which time the committee was briefed in depth on all aspects of the chemical test program, current and proposed. Details of a recently developed aggressive program of research and technology to further assure safe testing at Dugway Proving Ground, program SAFE (app. B), were presented. The group toured Dugway Proving Ground and inspected the technical, scientific, and medical facilities, talked with key scientific and engineering personnel, and reviewed Dugway's safety procedures and regulations. The committee held three additional meetings in the Washington, D.C., area during the periods September 5 through 6, 1968; October 3 through 4, 1968; and November 7, 1968. In addition, several members made independent visits to certain of these activities for additional technical conversations.

A comprehensive safety program has been in effect for more than 17 years at Dugway Proving Ground and has been very successful as is evident from the following evaluation. It is estimated that 9,708,696 man-hours have been expended in direct support of mission programs and that of this total 25 percent, or over 2,400,000 man-hours, have been worked in hazardous environment involving handling, filling, testing, laboratory analysis, and disposal of toxic materials requiring the use of special protection in the form of protective clothing, masks, and environmental controlled work areas and special safety techniques and procedures. During this period, 221 persons were treated or observed as the result of possible exposure to chemical agents, of whom 17 were given some treatment. None of the exposures were considered critical or severe and none of the exposed personnel had demonstrable lasting effects. No fatalities have occurred from exposure to chemicals.

The death of the sheep in March 1968 provided the first offpost event which was suspected of being connected to Dugway operations. The outstanding success of Dugway's safety procedures and planning must be conceded; however, the ever-present need to extend the existing program to accommodate handling and testing new weapons systems is also evident.

III. HISTORY

Dugway Proving Ground was established in March 1942 to serve as an isolated testing site for large-scale evaluation of chemical munitions. The installation was operated by the Technical Division of the Chemical Warfare Service (later the Chemical Corps) but worked closely with the other branches of the Armed Forces as well. During World War II the types of tests conducted ranged over the entire gamut of chemical warfare, from smokes and incendiaries to chemical agents. Of particular importance were the extensive nonpersistent chemical tests conducted in the summer of 1943; the incendiary tests conducted on simulated German and Japanese villages from 1943 until the end of the war; a large spray program run in the summer of 1944 involving release of hundreds of tons of mustard gas; and the investigation of means of attacking Japanese cave defenses. Among the most important work accomplished at Dugway during this period was the development of the 4.2-inch chemical mortar which was used with great success in all theaters of the war. From 1942 through 1946 Dugway was an independent installation, but in 1946 it was combined with the Deseret Chemcal Depot, not to be confused with the present Deseret Test Center, to form the Western Chemical Center.

In July 1950, at the outbreak of hostilities in Korea, Dugway was reactivated as an independent installation. All operations were resumed in the original facilities located in what is now Ditto Technical Center, approximately 10 miles west of the present main gate. Additional facilities and units, including a medical detachment, a military police detachment and a chemical battalion, were also added to the original technical service unit. Plans were initiated in 1950 for new technical facilities in Ditto Technical Center and at the test sites and for a new residential and administrative area now known as English Village. The greatest part of this contruction was completed by 1952.

Since 1952, Dugway Proving Ground has grown in size and increased the scope of its activity. The responsibility for the Chemical Corps environmental pro-

gram was assigned to Dugway in 1953. This responsibility included the administration, direction and staffing of selected environmental test activities. The responsibility for meteorological research and development related to the CB program was assigned to Dugway Proving Ground in 1953.

In 1962, under the President's Army Reorganization Plan, Dugway Proving Ground was released from its assignment to the Chemical Corps Research and Development Command and assigned to a major subordinate command of the U.S. Army Materiel Command; namely, the U.S. Army Test and Evaluation Command with headquarters at Aberdeen Proving Ground, Md.

The Deseret Test Center (DTC) was established at Fort Douglas, Utah, in 1962 as a special project under the jurisdiction of the U.S. Army Materiel Command. The Center is a joint activity, with military personnel from the Departments of the Army, Navy, Air Force, and U.S. Marine Corps and civilian personnel from the Department of the Army. The Center coordinates Armed Forces interests in defensive chemical and biological testing. On July 1, 1968, Dugway Proving Ground and Deseret Test Center were consolidated and established as the Deseret Test Center, with headquarters at Fort Douglas, Utah, Dugway Proving Ground being designated an element of DTC.

IV. DISCUSSION

A. As the committee reviewed the safety measures applicable to testing of chemicals at Dugway Proving Ground (DPG), it became apparent that as a result of the death of the sheep a new approach to the total safety picture must emerge. Essential data must be obtained to insure that the future conduct of chemical tests at the Proving Ground will not constitute a hazard to humans, animals and plants within and outside the boundaries of the proving ground. Specific categories of information must be available and understood. These have been categorized as follows:

1. Characteristics of agents.
2. Toxicity.
3. Fate of agent in environment.
4. Monitoring for chemical agents.
5. Meteorology.
6. Medical facilities and procedures.
7. Community relations.
8. Public information.

These categories will now be discussed in detail.

B. Characteristics of agents:

1. For the purpose of discussion and for developing recommendations to improve safety in testing programs at Dugway Proving Ground, the committee categorized agents and munitions as—

(*a*) Riot control agents and munitions—chemicals of low lethality and brief activity.

(*b*) Incapacitating agents and munitions—chemicals of high toxicity but low lethality; they may be either persistent or nonpersistent in type.

(*c*) Nonpersistent lethal agents and munitions—chemicals of high toxicity and lethality of nonpersistent type.

(*d*) Persistent lethal agents and munitions—chemicals of high toxicity and lethality of persistent type.

(*e*) New and/or more toxic agents and munitions—may be either of persistent or nonpersistent type.

2. The committee used a wide spectrum of characteristics, safety requirements and other criteria in developing these five classes. The characteristics considered include physical, chemical, and biological properties. The five classes of agents and munitions are based also on differential requirements for safe testing. In addition, other criteria involved in this plan are toxicity, persistence, and fate in the environment. The five classes involve also judgment factors based on the end uses and the requirements for testing prior to use.

3. Chemicals of the first three types, being either of low lethal activity, of low persistence in the environment or of brief biological activity present comparatively small hazards to the lives of exposed men or animals and comparatively little danger of hazardous secondary intoxication by ingestion of contaminated plants or animals or by other contact with such materials.

The committee feels, therefore, that testing with such chemicals can be performed safely within the framework of current practices and safety procedures. The committee did not address category 5. This type can only be reviewed as required by a permanent Chemical Safety Committee, which, in the present committee's opinion, should be established as soon as practicable to advise the commanding general, Deseret Test Center, on a continuing basis. The restraints placed on category 4-type agents and munitions will be discussed in appropriate succeeding sections.

C. Toxicity:

1. Knowledge of the toxicity of any compound to be released into the environment during tests at Dugway Proving Ground is an important part of the pretest evaluation of the chemical. The safety of people and animals living not only in the immediate area of the test but also within several tens of miles of the point of release of the compound must be considered along with the aggressive characteristics of the chemical. The following outline of information required about the toxic properties of any chemical to be tested, either as an agent alone or as a component of a munition, seems to the committee to be the smallest body of knowledge that can furnish reasonable guidance on safety to the planners and supervisors of a test program.

(*a*) Determination or estimation of the toxic and lethal activities of single and repeated doses by intravenous (i.v.), itramuscular (i.m.), subcutaneous (s.c.), inhalation, oral and cutaneous administration to animals and humans of both sexes and all ages and to pregnant females needs to be established. The importance of studies of low-dose, chronic administrations of chemicals is recognized.

(*b*) Estimation must be made of the persistence of toxic residues of the compound on ground, on plants and in water supplies, including snow, on test sites and in the immediate vicinity (up to several tens of miles away) of the test sites at all seasons of the year. At Dugway Proving Ground, such studies will include the major soil types and indigenous plants such as juniper, shadscale, budsage, white sage, greasewood, and pickleweed. Adsorption and absorption by plants must be studied for each individual chemical, using toxicity as the initial indicator of the presence of a hazardous chemical. If plants do become toxic after exposure to a chemical, studies to determine the molecule or molecules responsible for toxicity will be conducted.

(*c*) Determination or estimation be made of the toxic and lethal activities on animals, both domestic and wild, likely to be exposed to the chemical during a test and on man of repeated oral or cutaneous doses during the experimentally determined period of persistence of the chemical and its residues in the environment. This study should include both sexes of all ages and pregnant females. The possibility that indigenous fauna contaminated by a chemical, and weakened although not yet killed thereby, may be caught and eaten by such domestic animals as the cat and the dog should receive some attention also. Effects directly on indigenous fauna may be important indicators that an agent has gotten out of control.

(*d*) Estimation be made of the additive and synergistic action of a chemical to be used in a test with the toxic and lethal actions of pesticides and known poisonous forage plants, halogeton for example, indigenous to the area within or around Dugway Proving Ground.

2. A survey of the toxicity information available on VX on June 14, 1968, disclosed that values for the LD_{50} by various routes of administration were available for the mouse, the rat, the guinea pig, the rabbit, the cat, the dog, the monkey, and the chimpanzee among laboratory and pet animals. Values were available also for the pig, the goat, and the horse among domestic animals. No information was available on the sheep, the most important domestic animal in the vicinity of Dugway Proving Ground, or on any of the wild species living in that area. Toxicity for representative species of wild animals from the testing area is important to indicate the most sensitive of these species to the chemical under test, and, therefore, the best natural signals of penetration of the chemical into the general environment.

D. Fate of agent in environment:

1. The numbers and kinds of plants, animals, soils and the chemical, physical, and biological properties of the water and atmosphere at the

Dugway Proving Ground test site and an offpost border area within a radius of several tens of miles adjacent to the test site must be known and understood. A thorough knowledge of the micro and macro ecology and climatology of the area must be developed. Such information is a prerequisite to an understanding of the behavior and fate of chemical agents in the test site at Dugway Proving Ground and in the offpost adjacent areas and is an integral part of the safety requirements for current and future types of testing at Dugway. The characterization criteria are as follows:

(*a*) *Absorption or uptake.*—The absorption or uptake of chemicals by plants and animals is critically important. Chemicals may enter plants through their roots or leaves. They enter animals by ingestion, inhalation, or absorption through the skin. Chemicals that are absorbed by plants may be absorbed by the roots of plants and translocated to the aboveground parts where they accumulate in the stems, leaves, and fruits. Many are also absorbed by the leaves of plants and are readily translocated to the roots. Species of plants vary widely in their efficiency to absorb chemicals from soil, water, or air through their leaves and roots. In many instances the tolerance of plants to chemicals is based on the differential absorption and translocation of chemicals from the soil, water, and air. The absorption and translocation of chemicals in food, feed, and forage plants is an important method by which chemical toxicants are removed from the environment and incorporated through the food chain into the bodies of humans, domestic animals, fish, wildlife, and other living organisms. Knowledge of the uptake and movement of chemical agents then becomes an integral part of the safety requirements in testing operations.

(*b*) *Adsorption.*—Most chemicals are adsorbed by plants, soils, water, animals, and airborne particulates. The tenacity with which they are bound varies greatly among plants, animal tissues, soil types, and other surfaces. Adsorption by soils also varies greatly with their chemical, physical, and biological properties. Adsorption in water depends largely upon the chemical, physical, and biological properties of the water and is greatly influenced by the amount of sediment and organic matter it contains. The adsorption of chemicals in air depends upon the airborne particulates and their chemical, physical, and biological properties. The activity of most chemical agents varies with soil composition. In soil systems, adsorbed chemicals are gradually desorbed as leaching or chemical and biological degradation occurs, and absorption by plans reduces the concentration in the soil solution. However, the adsorption-desorption relations of chemical molecules in soils and the importance of these phenomena in the movement of chemicals in soils should be determined for the soil types and environmental area surrounding Dugway Proving Ground.

(*c*) *Translocation or movement.*—Numerous factors influence the translocation of chemicals in plants. Once a chemical has been absorbed into the plant it may be immobilized in the treated tissue by adsorption to, or conjugation with, cell constituents. When some chemicals are absorbed the molecule is often metabolized prior to translocation. Food, feed, and forage plants are a primary sink for chemicals released into the environment. They are a major means through which exogenous chemicals in the environment enter human and animal bodies. Therefore, the safe testing and use of chemicals in the environment demand a knowledge of their absorption, movement, translocation, mechanism of action, metabolism, and toxicity to plants and toxicity to humans and animals that consume plants containing such chemicals.

(*d*) *Metabolism and metabolites.*—The ability of animals and plants to convert nontoxic chemicals to toxic metabolites and to detoxify highly toxic chemicals has been well established in studies on the mechanism of action and metabolism of herbicides, insecticides, fungicides, nematocides, and other chemicals. It has also been demonstrated that similar conversions of chemicals can occur in soil, water, and air. It is therefore important to safe testing and the safe use of chemicals to understand the conversions chemicals undergo in plants, animals, soils, water, and air. In some cases, the metabolite might be less toxic than the original molecule and in some instances the resulting metabolites may be even more toxic than the original molecules. It is therefore imperative to determine the toxicological properties of the original molecule as well as those of its degradation products, intermediates, and metabolites.

(*e*) *Volatility.*—All chemicals evaporate to some extent from the surfaces of plants, soils, water, animals, and airborne particulates. The degree and rate of their volatility is a major factor in the control of their distribution and move-

ment. For this reason, the rate of evaporation should be determined from plants, soil, water, animals, and airborne particulates at a temperature 10 degrees lower than the lowest temperature and 10 degrees higher than the highest temperature recorded at Dugway Proving Ground. The effects of such factors as temperature, pH, soil type, vegetative cover, wind velocity, and other factors known to influence volatility of chemicals should be determined. It is especially important to understand the impact of particle size on volatility in relationship to deposition of chemical agents on targets.

(*f*) *Photochemical changes.*—Studies have established the fact that chemicals are subject to photochemical changes in plants, soils, water, and air. The effect of photochemical changes on chemical agents should be determined by exposure of such agents to various light spectrums at a range of temperatures and other conditions that effect photochemical changes in chemicals.

(*g*) *Chemical reactions.*—Some of the chemical reactions that chemicals undergo in plants, soils, water, animals, and air have already been discussed. Many chemicals are known to undergo hydrolysis, oxidation, and the formation of complexes in plants, soils, water, and air. The chemical reactions that organic chemicals will undergo in plants, soils, water, animals, and air are numerous. These chemical reactions need to be understood for maximum safety in testing and use.

(*h*) *Persistence.*—An understanding of the persistence of chemical agents in plants, soil, water, animals, and air is essential in developing appropriate safety monitoring techniques. The persistence of chemical agents in the various soil types and the vegetative associations in the off-post areas surrounding Dugway Proving Ground, as well as the persistence of chemical agents in water, in animals, and in the atmosphere must be known.

(*i*) *Degradation.*—An understanding of the degradation of chemicals in plants, soils, water, animals, and the atmosphere is essential to safe testing techniques. Degradation may occur through microbial action, volatility, chemical reactions, photodecomposition, and other processes. The process of degradation in plants, soil, water, animals, and air should be understood and the rate of degradation determined.

(*j*) *Dissipation or excretion.*—Degradation of chemical agents does not always mean they have dissipated. The processes and rate of dissipation from plants, soils, water, and air should be known, as well as the rate of excretion from animals.

(*k*) *Disposal and decontamination.*—Methods of disposal and decontamination should be available or developed for onpost and offpost use.

2. A number of criteria for characterizing the behavior and fate of chemical agents in plants, soils, water, animals, and air have been discussed. Obviously, the necessity for, and thoroughness of, the fundamental data required on the behavior and fate of each chemical in plants, soil, water, animals, and air can vary depending on an assessment of the risk of the chemical agent reaching off-post locations inhabited by man, domestic animals, and wildlife. The greater the risk of the agent reaching off-post locations, the greater that need and the degree of understanding of the behavior and fate of the agent in the environment. It is therefore obvious that the thoroughness of understanding of the behavior and fate of the agents in the environment will have a significant impact on the development, implementation, and management of safety programs associated with testing at Dugway Proving Ground.

E. Monitoring for chemical agents:

1. There is a need for Deseret Test Center to develop and implement a monitoring program designed to detect the immediate presence and/or verify the absence of chemical agents in areas outside the Dugway Proving Ground grid areas, including the off-post areas contiguous to the proving ground. This program should supplement the current on-going ecology and epidemiology effort.

2. Background data has been made available by the Department of Army which is of value in making recommendations for the chemical agent monitoring program. The offpost human population consists of ranchers who live in Skull Valley and ranchers and inhabitants of small communities who live in Rush Valley, north and east of Dugway Proving Ground. Horses and cattle graze on the private land and Bureau of Land Management (BLM) land in both valleys throughout the year. Sheep graze the private and BLM lands in Skull Valley and the area west of Cedar Mountains from November to May. The area west of Dugway Proving Ground consists of relatively barren salt flats which support little or

no plant or animal communities. DPG is located adjacent to the old shoreline of the Great Salt Lake. The terrain on DGP varies from sand dunes areas to flat desert lands adjacent to the low lying Cedar Mountains. The predominant DPG ecosystems have been characterized, and consist of shad scale with grey molly, greasewood or sage. The low mountains which border DPG on the northeast and which extend to Highway 40 have juniper and mixed brush plant communities. The valley west of the Cedar Mountains, Skull Valley east of the Cedar Mountains, and Rush Valley east of the Sandsbury Mountains have shad scale, grey molly, greasewood and sage. The valleys and low mountain areas support large populations of the white footed deer mouse (*Peromyscus maniculatus*) and the horned lark (*Eremophila alpestris*). Many of these areas also have large populations of other wild mammals including various species of kangaroo rat (*Dipodomys*) and jack rabbit (*Lepus*). These mammals and birds are present and can be trapped throughout the year. They live intimately with the soil, plants, and insects in the area. They feed upon seeds, leafy portions of plants, and insects. Their population dynamics are reasonably well understood; for example, the various natural stresses which affect their density, reproduction, and longevity have been studied by the DPG ecologists. Data is available on their food, ectoparasites, diseases, predators, ecosystem associations, and seasonal fluctuations. However, the present ecological program at DPG is not designed to detect the subtle biochemical and physiological changes or changes in mortality rate which must be included in a sensitive chemical agent monitoring system.

3. The chemical agent monitoring system should consist of 10 permanent sites of about 5 acres each located west of the Cedar Mountains, east of the Cedar Mountains in Skull Valley, and east of the Standsbury Mountains in Rush Valley. At each site there should be a regular sampling schedule designed to detect immediately the agent chemicals or their degradation products in the environment. There should also exist a sentinel system designed to detect the biochemical or physiological effects of the agent or its products upon indigenous wild animals and domestic animals. Samples of soil, water, snow, and plants from each monitoring site should be tested at least monthly throughout the year to establish a baseline for the chemical compounds which are to be expected in the environment. It is important in this connection to document the presence of agricultural toxicants which have a structure and effect similar to certain of the chemical agents. An alarm system should be developed based on an air sampler which automatically tests for the chemical agents. Such an air monitoring device could be located at each permanent monitoring site and could be activated only when test conditions indicate a need for air samples. This system should provide an early warning of the presence of chemical agents in the area. However, the lack of sensitivity of such a system may limit its usefulness.

4. In contrast, the death of the sheep has shown that the effects on a susceptible animal can serve to indicate the presence of low levels of chemical agent. In the case of the death of the sheep, the levels of chemical agent were so low that the chemist could not readily detect the agent in environmental samples. Sheep proved to be uniquely sensitive sentinel animals because they are susceptible to the chemical agent; they exhibit readily discernible effects and they consume 3 to 5 pounds of plant material per day and eat snow, or drink water, in comparable quantities during their grazing. Even a low concentration of toxicant per gram of plant material or per square yard of rangeland may be sufficient to cause a clinically apparent effect, since the animal consumes so much of plant material. Furthermore, one need not rely upon only the clinically apparent changes. Blood and urine specimens can be taken regularly from sheep to determine significant biochemical changes or to search for the presence of chemical agent or metabolites.

5. Other animals may be even better suited for a continuous monitoring system. If the toxicology program can provide experimental evidence that indigenous wild mammals or birds are sufficiently sensitive by the dermal, respiratory, and oral routes, they could serve as a very effective natural monitoring system at the permanent monitoring sites. These animals have the obvious advantage of living throughout their lives in the monitoring site. Their population dynamics are reasonably well understood. The limited home range and short life span of indigenous rodents permits conclusions as to time and place of exposure. Accordingly, and contingent upon the establishment of their sensitivity to minimal doses via the three important routes of exposure, it is recommended that some ubiquitous small rodent species such as the deer mouse be considered as an appro-

priate sentinel animal. Each permanent monitoring site should therefore include a permanent grid area with trapping locations at regular intervals. Deer mice should be live trapped at each trap location every week, marked and released, and data on their population dynamics recorded throughout the year. Particular attention should be given to unusual changes in age structure, breeding success, home range, migration, longevity, food, and causes of unusual mortality. Separate transects could be established, radiating out from the grid area, from which deer mice could be regularly removed for testing purposes. These animals should be tested for the chemical agents and appropriate degradation products to define the lethal, toxic, and biochemical effects of these agents such as depression of cholinesterase levels.

6. Study of the small mammal populations may offer additional advantages. Their ectoparasites have been carefully studied over the past several years in the DPG areas. If it can be shown that low levels of chemical agent affect the fleas, ticks, mites, or lice on these small mammals, then regular estimations of the ectoparasite densities among the sentinel populations might provide evidence of the presence or absence of chemical agents.

7. While monitoring sites might be located around DPG in every direction, the committee feels the most urgent need for a monitoring program to detect chemical agents is in those areas where people and domestic animals are present. Furthermore, wind direction could be used in such a manner as to limit concern only to those areas north and northeast of DPG. Accordingly, it is recommended that there be two permanent monitoring sites in Rush Valley and five sites in Skull Valley where people and domestic animals live. Additionally, three sites should be located on the west side of the Cedar Mountains where sheep and cattle are permitted to graze. These sentinel sites should be distributed in a north-south direction, extending from about north latitude 40° 10′ to 40° 45′. Their location must take into consideration the need to have each site serviced by DPG personnel at regular intervals.

8. Since the citizens of Utah are primarily concerned about the health of human population and domestic animals, the monitoring program should provide for an agreed upon routine visit of a competent veterinarian to each herd of domestic animals, in order to reassure rancher, health officials, and DTC officials as to the health of these animals. It is further suggested that a State health department physician visit the ranchers who live in Skull Valley at least every 6 months. The U.S. Public Health Service supported community pesticide study in the Utah State Health Department might be augmented as required to provide testing of samples from human inhabitants, domesic herds, and the environment.

9. The committee is impressed by the need for detecting the presence of chemical agents, but it is also impressed by the need to reassure the populace as to the absence of chemical agents. The monitoring program is expected to generate negative evidence. Such negative evidence is at best tenuous, but can be considered of value only if the testing program has been sufficiently extensive and intensive to have detected an agent if it were present in biologically significant concentrations. This provides the best type of evidence for dealing with any charges that chemical testing at Dugway Proving Ground is a threat to the people of Utah or the neighboring countryside.

F. Meteorology:

1. The physical processes transporting, diluting, and depositing any pollutant in the atmosphere are well known. To predict downwind concentration or deposition requires characterization of source (point, volume, or line; physical properties such as particle size; release altitude(s) and most important, quantity), nonconservative behavior in atmosphere (evaporation of droplets, photochemical decomposition or alteration, and so forth), settling of particles in still air (size, shape, and density), bulk transport and dilution (which are functions of time, space, and meteorological variables) and finally deposition (precipitation or dry weather).

2. Atmospheric processes play a vital role in the safety program at Dugway Proving Ground. Once the mode and amount of agent release has been prescribed for a test, a plan is sought to see if and how the atmosphere may provide the necessary degree of safety. Three possible processes may achieve dosages in uncontrolled downwind areas which would be considered nonhazardous.

(*a*) Maximize deposition over controlled areas. A number of factors control the fraction of the solid or liquid agent which settles out over a nearby controlled region.

(1) The height of release: The lower the altitude, generally speaking, the sooner the deposition. It is suggested, for example, that no release take place at heights over 300 feet above terrain.

(2) The particle or droplet size and density: The larger and heavier the mass, the faster it falls. Every effort should be made to disperse agents as particles or droplets larger than 100 microns. Particulates or droplets ≧100 microns fall from 300 feet to the ground in about 5 minutes according to Stokes Law.

(3) The windspeed which determines the transport distance during descent: By selecting low speeds, one improves the chances for deposition near the point of release.

(4) Evaporation of droplets: When it occurs evaporation reduces local deposition and should therefore be minimized.

(*b*) Control cloud trajectory and maximize dilution. Since the height of release and nature and amount of agent will be prescribed by test requirements, only atmospheric parameters remain flexible. Two aspects of air motion should be distinguished:

(1) The mean wind bodily transports the whole cloud: By selecting appropriate mean wind directions, the cloud may be confined to a preassigned downwind sector. This sector may lie to the north and northwest of the Dugway test areas as shown in appendix A. The extensive controlled area of the Dugway Proving Ground is supplemented by the Wendover Bombing Range. This sector contains little vegetation, no domestic animals and no people until Highway 40 is reached. Further, winds blowing generally from the south-southeast into this sector occur with moderate frequency. Strict control over an extended area through which a chemical agent cloud may pass represents a modification in the Dugway approach for weather utilization. Heretofore, dilution of the cloud to nonhazardous concentrations played the most vital role so that conditions conducive to fastest mixing rather than confidence in the cloud path were preferred.

(2) Turbulent winds which dilute the cloud, thereby reducing the maximum concentration: Changing wind direction and/or speed with altitude enhances horizontal cloud growth while vertical convection as occurs on hot afternoons increases vertical diffusion. Generally, dilution is aided by strong windspeeds.

(*c*) Scavenge by precipitation over controlled areas. A third possibility for reducing agent concentration might be precipitation scavenging of the agents onto a controlled area. This possibility is not promising because—

(1) The desired test conditions preclude precipitation during the active test period.

(2) Unpredicted precipitation over subsequent uncontrolled areas may increase the hazard.

(3) As of the present, the fraction of the agent deposited in precipitation is unknown.

(4) The predictability of scattered showers at specific locations is poor.

3. Some meteorological requirements which increase safety are contradictory. Thus, convection which ultimately enhances vertical mixing may reduce local deposition by carrying blobs of the agent cloud aloft. Weak winds, which keep both the deposited particles closer to the release point and the cloud longer over Dugway Proving Ground and Wendover Bombing Range, are more difficult to predict.

4. Two new factors must be introduced into the weather forecast as a consequence of the death of the sheep in March 1968.

(*a*) Whereas concern was formerly restricted to a few miles from the release, it must now be extended to several tens of miles. This enlargement considerably increases the forecast difficulties for the meteorologist. It highlights the need to predict meso-scale weather systems whose dimensions lie between 1 and about 50 miles. To cope with this new weather scale, Dugway Proving Ground may require additional satellite weather stations surrounding the test area, for example, near topographic barriers to the air flow, and techniques to measure temperatures and winds well above the ground. As with existing weather stations in the Dugway network, provision for rapid communications and processing must be included as part of the observating program. The new scale of forecasting calls for a two-pronged program.

(1) The existing capability to forecast the movement and dilution of atmospheric tracers at the proving ground to distances of several tens of

miles should be established. Experience elsewhere suggests that considerable skill in predicting cloud trajectory can be achieved when the weather situation is carefully chosen, for example, when the local wind pattern is dominated by a slowly moving or stationary large-scale rather than a meso-scale weather system. Estimates of dilution can be made even today with information from tracer tests elsewhere. These can be applied to the dilution at Dugway Proving Ground with appropriate safety factors of between 10 and 100. In the absence of firm information concerning present Dugway Proving Ground forecast capabilities, one should proceed with the utmost caution in selecting test days and in assigning confidence limits for the trajectory and dilution uncertainties.

(2) A program to improve the forecasting capability should be implemented without awaiting the results of present day forecast capability. Numerical forecasting methods being developed elsewhere should be exploited whenever possible. Experience elsewhere indicates that, in general, the forecast capability leaves much to be desired. Such research may eliminate some of the weather restrictions and reduce the margin of safety which must now be imposed due to imperfect forecasting.

(*b*) The death of the sheep also suggested the possibility that precipitation scavenging may be a crucial contributor to hazard from the dispersal of chemical agents in the atmosphere. Until the effectiveness of such scavenging is established, precipitation should be avoided for at least 8 hours after release time. In the meantime, a program to understand the role of precipitation scavenging should be pursued by the Department of Army.

5. Three other meteorological aspects deserve attention:

(*a*) It is well known that some particles on the ground are resuspended by the action of the strong wind which can occur at Dugway Proving Ground. Some soil or other particles in the test area may be heavily contaminated by chemical agents. While it is the opinion of many that offpost hazard from such resuspension of contaminated soil is inconsequential, the matter deserves experimental confirmation.

(*b*) The extensive weather records at Dugway Proving Ground should be categorized so as to ascertain the consequences of various weather restrictions in the test activities.

(*c*) The trajectory, dilution, and deposition of all significant releases of chemical agents should be documented to sevaral tens of miles insofar as possible. These reconstructed histories of cloud behavior can provide experience for future events and guide the interpretation of monitoring information. In some instances, the immediate estimates of cloud paths may contribute to emergency operations.

G. Medical facilities and procedures:

1. Hospital facilities at Dugway Proving Ground consist of a hospital which is authorized 15 beds with a capability to expand to a total of 35 beds. There is no plan for evacuation of casualties to other service or civilian hospitals in the event that present facilities are inadequate. For treating small numbers of personnel who might become victims of chemical test agents, the onpost "change house" provides a treatment area where decontamination can be performed as well. The post dispensary can be used for treatment, if necessary, of personnel exposed to chemical agents. There are no active decontamination facilities available in the Ditto area; however, procedures for use of standby facilities are established in appropriate safety directives and standard operating procedures. Protective equipment and decontamination materials for individual protection and instrumentation, aircraft and area protection is available onpost. Detailed procedures providing responsibilities, training and use of this equipment and material are available and implemented by numerous SOP's and Dugway Proving Ground regulations.

2. U.S. Army Hospital, Dugway Proving Ground is authorized 96 medical personnel. This total authorization includes six physicians, three dentists, one veterinarian, five military nurses, two medical administrators, 62 enlisted men and 17 civilian spaces (including five civilian nurses).

3. Physicians arriving at Dugway Proving Ground for duty are scheduled to attend the CBR weapons orientation course in August and February for 1 week's general background training. All physicians are provided briefings on diagnosis and treatment of patients who may be exposed to chemical agents. In addition, physicians involved with providing onpost care during actual agent

testing are given the safety briefings provided all personnel participating in the specific test. Medical auxiliary personnel (nurses, dentists, enlisted technicians, and hospital civilian employees) receive only the special training required for their assigned tasks, and no special program of instruction in treating or handling chemical casualties is provided. Eight enlisted corpsmen are trained in first aid for chemical casualties and are assigned to support test operations.

4. Instituting medical procedures which are necessary to meet any contingency of testing chemical agents or simulants is ultimately the responsibility of the commander. Medical and safety staff officers provide advice and assistance to all operating elements of Dugway Proving Ground involved in operations with hazardous materials. Specific medical and safety responsibilities are identified and assigned in test directives and in standard operating procedures and regulations. These directives are written and coordinated with the Dugway Proving Ground military and civilian staff, and prior to July 1968 were reviewed by the Test and Evaluation Command (tecom). They are now reviewed by headquarters, Deseret Test Center.

5. Rigorous planning is followed in the design of tests involving toxic and infectious materials. The specific of establishing test parameters concerning such subjects as amount of material released, meteorological limitations, and other positive control methods are discussed elsewhere. The test plans developed for various test programs are, in effect, specific procedures which have the most direct bearing on the safety aspects of the test as they relate to the potential exposure of humans, animals, and plant populations both onpost and offpost.

6. Review of available test planning directives demonstrate their exceptional adequacy for onpost safety and medical responsibilities and procedures. There is only very general direction for "effecting necessary coordination with all agencies involved" which would, presumably, include State and Federal health and agricultural agencies vitally interested in measures to protect offpost civilians, livestock, and grazing areas should an accident occur. These general directions should be specific as to with whom and when this coordination is accomplished. Coordination, liaison, and planning should be accomplished with representatives specified by outside organizational entities such as the State public health director, county health office, the regional U.S. Department of Agriculture and Department of the Interior offices, and the Bureau of Land Management.

7. Safety consciousness of medical, professional, and auxiliary personnel involved in the planning or execution of test missions is evaluated as very good based on knowledge of training, equipment, and test procedures. In the area of coordination, knowledge and planning for mass casualty disasters, involving military or civilian populations not directly or indirectly concerned wth chemical testing, there appeared to be either a lack of complete orientation of medical personnel or incomplete planning for the rare, unexpected accidental exposure of groups of personnel not involved with testing who live on Dugway Proving Ground or in areas surrounding the test installations. However, it should be noted that this problem is being rectified.

8. Each test plan at Dugway Proving Ground contains specific intructions on the types and quantities of protective clothing and equipment to be used for that test. In addition, Deseret Test Center safety regulations provide direction concerning—

(*a*) Personnel who require protective clothing and equipment;

(*b*) Responsibilities of supervisors and the individuals who use the equipment;

(*c*) Procedures for ordering and issue of protective clothing; and

(*d*) Control of the equipment while in use.

9. A permanent decontamination station is located at the V grid area. Whenever toxic chemicals are used in other areas, a portable decontamination station is used. A hospital van is present at the V grid when toxic agent tests are conducted. An ambulance is present on all tests. A medical officer's presence is essential at all toxic tests.

10. A safety officer is present at each test to advise the test director on all aspects of safety which might arise during the test. Prior to the death of the sheep, the safety officer did not possess authority to halt tests which he might consider unsafe. This authority has now been delegated to the safety officer. Safety consciousness among safety personnel is very high, and evidence of deand present test missions is amply demonstrated. The remarkable safety record tailed planning, liaison, and knowledge of equipment and procedures for past

at Dugway Proving Ground is further evidence that the enormous effort and careful execution of the safety aspects of each test are successful.

11. Safety procedures as applied to selected employees and nonemployees are as follows:

(*a*) Selected employees: These personnel include contractor employees, nonappropriated fund employees, and employees ordinarily working in areas certified as "clean" by the safety officer. Contractor employees receive orientation in range control and traffic procedure. If they must enter a contaminated area, they are then briefed on masking, the use of clothing, and other necessary safety procedures. All other employees receive an initial "new employee orientation," which includes a safety portion covering traffic safety, industrial or occupational health safety, and work safety involving hazardous areas. In addition, each supervisor conducts safety training or notifies the range and agent control officer who arranges for special training when any potential or active hazardous agent tests are to be conducted. Each employee who "may in the course of their duties need to enter a chemical hazardous area more than twice yearly" will receive appropriate blood cholinesterase determinations before access to hazardous areas is permitted. Current listings of all hazardous and temporarily hazardous areas and of individuals cleared for access are maintained by the range and agent control officer. Other determinations will be made as the need arises. All employees whose duties may bring them into contact with hazardous material are issued an emergency card, "Possible Exposure to Defense Materials" by the Safety Division. Instruction for employees, spouses, or near kin regarding unusual symptoms or actions due to toxic exposure are given, as well as medical and security measures to be followed. Safety consciousness of this category of employee can be judged only from the excellent record of the overall safety program. Requirements for training, equipment, and procedures related to safe practices while on the installation are detailed and effective.

(*b*) Nonemployees: Military and civilian dependents receive training only in traffic safety procedures. They receive no training in chemical hazards safety. Safety discipline and consciousness probably exist only in the area of traffic. To promote consciousness of any significant degree to cope with an accidental event which might occur only one time every 25 years is extremely difficult. Provision of a plan for evacuating the installation housing area (English Village) and a practical exercise of the plan periodically would appear to be a realistic and achievable objective to attain reasonable safety for these personnel.

H. Community relations:

1. Community relations is an essential part of any safety program of the Deseret Test Center. Even though all known precautions are taken during testing of chemical agents, safety planning must provide for the remote possibility of exposure to humans, animals, and vegetation offpost. The best way to insure solid community relations as an essential part of the safety program is to seek and obtain participation in the development and maintenance of any safety plan involving offpost protection. This includes knowledge by some community leaders, such as State officials, of the safety procedures of the tests themselves, the remote possibility of offpost contamination and the offpost precautions taken, i.e., monitoring to detect contamination. It also includes the development of a plan of action with appropriate community leaders, police, physicians, etc., to be used in the remote instance when the safety of human beings, animals, and vegetation may have been jeopardized. Without community involvement in the plan for offpost safety at the Deseret Test Center, Utah State officials, community leaders, and the public must rely on assurances of the U.S. Army that all precautions have been taken and that the testing is completely safe. Experience has shown in other situations that assurances given by the testing group reinforced by assurances of knowledgeable State officials and community leaders are much more readily acceptable by the public at large.

2. There are three essential elements involved in developing a good offpost safety plan of Deseret Test Center. First, there is the need for knowledge, both general and technical, on the part of certain county, State, and Federal officials of the activities of the test center, the safety procedures, and the offpost safety plan that has been developed. Second, there is the need for joint offpost monitoring by both Deseret Test Center and the State of Utah as part of the safety operation. And finally, there is the need for the development of a meaningful plan of action in the State in the unlikely event of offpost contamination with chemical agents.

(*a*) Need for knowledge: Certain Utah State officials, such as the Governor, the heads of the departments of health and agriculture and a few others require

general knowledge of the activities of the test center. This should include a general idea of the types of tests, the characteristics of the agents tested, and particularly the safety precautions onpost and offpost. They need to know the personnel who are chiefly responsible for the various phases of each test. General knowledge of this type permits these officials to speak to the public with some assurance if they are called upon to do so during an emergency. Ignorance of this background information is easily detectable in a public official when he speaks to the public. Such ignorance during the period of uncertainty when there may be an emergency will only serve to heighten apprehension in the public's mind. In addition to this general knowledge, certain Utah State officials need to have technical knowledge. These individuals are more likely to be the individuals actively involved in the offpost monitoring or in the implementation of an emergency plan and will require detailed technical knowledge of testing, agents involved, and monitoring for detection. In the State of Utah, these individuals would probably be in the department of health where there is already competence in this area, with appropriate liaison with the department of agriculture.

(*b*) Offpost monitoring: Offpost monitoring should be an integral part of the safety plan. Such monitoring should be conducted jointly by the Deseret Test Center and the State department of health in a pattern and with methodology jointly agreed upon. Monitoring offpost areas serves several purposes. Baseline data is essential to detect any change during testing. In the event of uncertainty of offpost contamination during a test, monitoring adds to the determination of certainty in either direction. It is more likely to provide the data that shows that contamination did not take place in spite of coincidental clinical illness in humans or animals in the surrounding area. Finally, if contamination did occur, it permits timely implementation of the emergency plan.

(*c*) Emergency plan: One of the most difficult parts of the community relations aspect of the offpost safety program, albeit an essential one, is the development and maintenance of a plan of action in the event of offpost contamination from testing of chemical agents. It is a plan that must involve a broader range of people in the community who must be made aware of the dangers of testing, however remote, and who must be prepared to take appropriate action if necessary. It is difficult because the likelihood of the plan ever being necessary is practically nil. For this reason, motivation for those who must be involved is low; even though they are sufficiently motivated during the early stages, interest is rapidly lost unless constant attention is paid to maintaining the state of readiness of the plan. An emergency plan must include an alert system, a decision point or points, and several courses of action which may be taken singly or in concert depending on the nature of the offpost emergency. It must also include some method of periodically refreshing the state of readiness. Development of the emergency plan will require the careful joint efforts of the Deseret Test Center, State officials, and certain key individuals in the surrounding area. Once the plan is developed, it is essential that the existence of the plan be widely known.

I. Public information:

In order to improve the rapport of the local populace with the Deseret Test Center, the committee feels strongly that the Department of Army should review its policy on public information on testing of chemical agents for possible provision of information before, during and after testing concerning the general nature of the tests and the comprehensive safety program associated with the tests.

J. Chemical Safety Committee:

The ad hoc committee is temporary in nature and can conduct only a one time review of the past and current adequacy of safety measures at Dugway Proving Ground. Since testing is a continuous mission and safety a constant part of this mission, the committee believes there is a high priority requirement to establish a permanent interagency technical safety committee advisory to the commanding general, Deseret Test Center. This committee once established should meet at least annually or on call as required by the commanding general, Deseret Test Center.

1. The purpose of the committee would be—

(*a*) To review and analyze Deseret Test Center programs in meteorology, test technology, chemistry, ecology, plant and animal physiology, toxicology and safety procedures.

(*b*) To examine the immediate and residual hazards to man, wildlife, domestic animals, and plants on and off test sites as related to test activities.

(c) To analyze and identify knowledge gaps in the Deseret Test Center test safety programs.

(d) To advise and recommend to the commanding general, Deseret Test Center, actions, safety criteria and procedures required for the safe transport, safe storage and disposal of chemical test activities.

2. Membership in the committee should bring to the commanding general high-level scientific talent found in branches of the appropriate scientific disciplines such as chemistry, ecology, meteorology, toxicology, soil science, plant and animal physiology, medicine and public health. Appropriate representation from the State of Utah should be included in the committee.

K. Program SAFE:

The committee was briefed in detail on program SAFE (see Appendix B). This program represents an aggressive, dynamic, comprehensive safety program that was developed by Deseret Test Center to assure safe testing in the future at the proving ground. The committee was much impressed by the scope of the effort and agrees that implementation of this program must be accomplished. Since the SAFE program is a dynamic and flexible effort, it should be responsive to the newer chemical agents and weapon systems now in research and development. The scope and results of this program should be reviewed at least annually by the permanent Chemical Safety Committee discussed above in paragraph J. The committee urges the Department of Army to support program SAFE to the maximum extent.

L. Land acquisition:

The recommendations of this report as to safety were based on the present size of Dugway Proving Ground and the Wendover Bombing Range. The question of acquiring management rights for additional areas was discussed. Information was too scanty to arrive at any judgment of the effects of acquiring management rights to additional land areas on the recommendations of this committee.

V. SPECIFIC RECOMMENDATIONS

The committee recommends that:

A. Test limitations

1. Testing of riot control, incapacitating and nonpersistent lethal agents and munitions be resumed without modification of current practices and safety procedures. The scale of testing must be consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man and representative indigenous animals and domestic livestock.

2. Testing of persistent lethal agents and munitions in quantities of agent not to exceed the equivalent of one artillery round, rocket, or mine be resumed without modification of current practices and safety procedures. The scale of testing must be consistent with available toxicological information so as to reduce to a minimum the probability of harmful effects to man, representative indigenous animals and domestic livestock.

3. Plans of test for programs involving persistent lethal agents in quantities greater than those specified in A2, above, will specify restraints in scope of testing and meteorological restrictions needed to comply with the following criteria: (These restraints should remain in effect until reviewed by a permanent Chemical Safety Committee recommended below.)

(a) The combination of windspeed, release height, and particle size shall be controlled to provide maximum depletion of the cloud within the initial downwind travel period. No release shall be made at heights greater than 300 feet; also, no significant fraction of the agent cloud shall be composed of particles smaller than 100 microns in size. Positive control of agent dissemination will be maintained by automatic flow devices, radar and radio control, by establishment of limitations on total quantity of agent dispersed and other available means when high performance aircraft are used for dispensing toxic chemical agents having properties equivalent to those of the nerve agent VX.

(b) The cloud shall remain in a sector betwen north and northwest of the test area and not cross U.S. Highway 40 for at least 3 hours.

(c) The windspeed at standard anemometer altitudes (10 to 30 feet) shall be as low as possible but no stronger than 15 miles per hour.

(d) No thunderstorms shall be present within 100 miles of the test site at release time nor predicted to occur within 100 miles of the cloud trajectory for at least eight hours from actual release time.

(*c*) Confidence in the weathter forecast shall be high; there must be past experience demonstrating the reliability of predictions from similar weather situations.

B. Toxicological research

1. Determination or estimation be made of the toxic and lethal activities of single and repeated doses of the chemical by intravenous, intramuscular, subcutaneous, oral, inhalation, and cutaneous injection or application, on humans or animals, including laboratory species, economically important species in the vicinity of Dugway Proving Ground, and representative wild species, living on or near Dugway, of both sexes and representative age brackets, and on pregnant females.

2. Toxicity and persistence of residues of the compound on test sites and other areas of Dugway Proving Ground be determined.

3. Determination or estimation be made of the toxic and lethal activities of repeated oral and cutaneous doses during the period of persistence, of the chemical and its residues, on humans or animals of both sexes and of all ages, and on pregnant females.

4. Estimation be made of the additional insult due to the chemical in foraging animals that have partaken already of known poisonous forage plants, halogeton for example, indigenous to the area of the testing facility.

C. Environmental studies

1. Determination be made of the presence and persistence of toxic residues of chemicals upon indigenous vegetation and of their absorption from the soil by indigenous plants; whether the plant decreases or increases the toxicity of the chemical after its absorption into the plant. Absorption, uptake, and metabolic transformation by the plant must be studied for each individual chemical agent.

2. Determination be made of the presence and persistence of the compound in soil and in water supplies, including snow, at all seasons of the year in the neighborhood of the testing site.

D. Monitoring for chemical agents

Deseret Test Center develop monitoring systems both within and outside the boundaries of Dugway Proving Ground for baseline data collection and to detect the presence of or verify the absence of chemical agents by both immediate responsive methods and by ecological monitoring. The system should be developed in coordination with the Utah State Department of Health and other appropriate Utah State and Federal agencies.

E. Community relations

1. Deseret Test Center shall take the initiative to inform certain key Utah State officials of the general nature of the activities of the Test Center and the relationship of testing to the community.

2. Deseret Test Center shall establish a mechanism with the Utah State Department of Health, Utah Department of Agriculture and other appropriate Utah State agencies for the exchange of technical information on chemical test planning as it relates to off-post monitoring and safety.

3. Deseret Test Center in collaboration with Utah State officials shall work with the communities surrounding the test site to develop and maintain a standby emergency plan of action. This will include an alerting system, a command point, and levels of action to be taken.

4. Deseret Test Center shall establish a procedure providing for liaison and coordination with designated civilian entities and agencies during test planning and testing of chemical agents which have any possibility of off-site dissemination.

F. Meteorology

1. The prediction capability for the transport, dilution, settling and deposition (including thunderstorm scavenging) of chemical agents to distances of several tens of miles be determined and improved.

2. Post-test estimates of cloud transport, dilution and deposition for all significant tests be routinely reconstructed.

3. Experiments to evaluate the resuspension due to wind action of deposited chemical agents be conducted.

4. A climatology of favorable testing period based on various weather restrictions be prepared.

G. Medical

1. Deseret Test Center and U.S. Army Hospital, Dugway Proving Ground shall develop a mass casualty plan to include specific care and evacuation procedures for patients exposed to chemical agents.
2. Deseret Test Center shall develop liaison and coordination procedures with outside medical resources to insure a feasible medical evacuation.
3. Deseret Test Center shall extend medical professional liaison to provide information and medical assistance to the civilian medical community.
4. Deseret Test Center shall conduct at least annual exercises to test mass casualty and medical evacuation procedures.

H. Public information

Deseret Test Center expand its public information programs for appropriate Utah State and Federal officials and for the public.

I. Chemical Safety Committee

A permanent Chemical Safety Committee advisory to the commanding general, Deseret Test Center be established. Representation from the State of Utah should be included.

J. Program SAFE

1. The recommendations of this committee be included in program SAFE.
2. The commanding general, Deseret Test Center be provided with sufficient funds and personnel to complete and implement the program.
3. Program SAFE be reviewed by the permanent Chemical Safety Committee as required.

K. Land acquisition

The Department of Army complete its study as to the feasibility of obtaining management rights for the additional land areas adjacent to the Dugway Proving Ground.

VI. MEMBERS OF THE INTERAGENCY AD HOC ADVISORY COMMITTEE FOR REVIEW OF TESTING SAFETY AT DUGWAY PROVING GROUND

Dr. William H. Stewart, Surgeon General, U.S. Public Health Service, chairman.

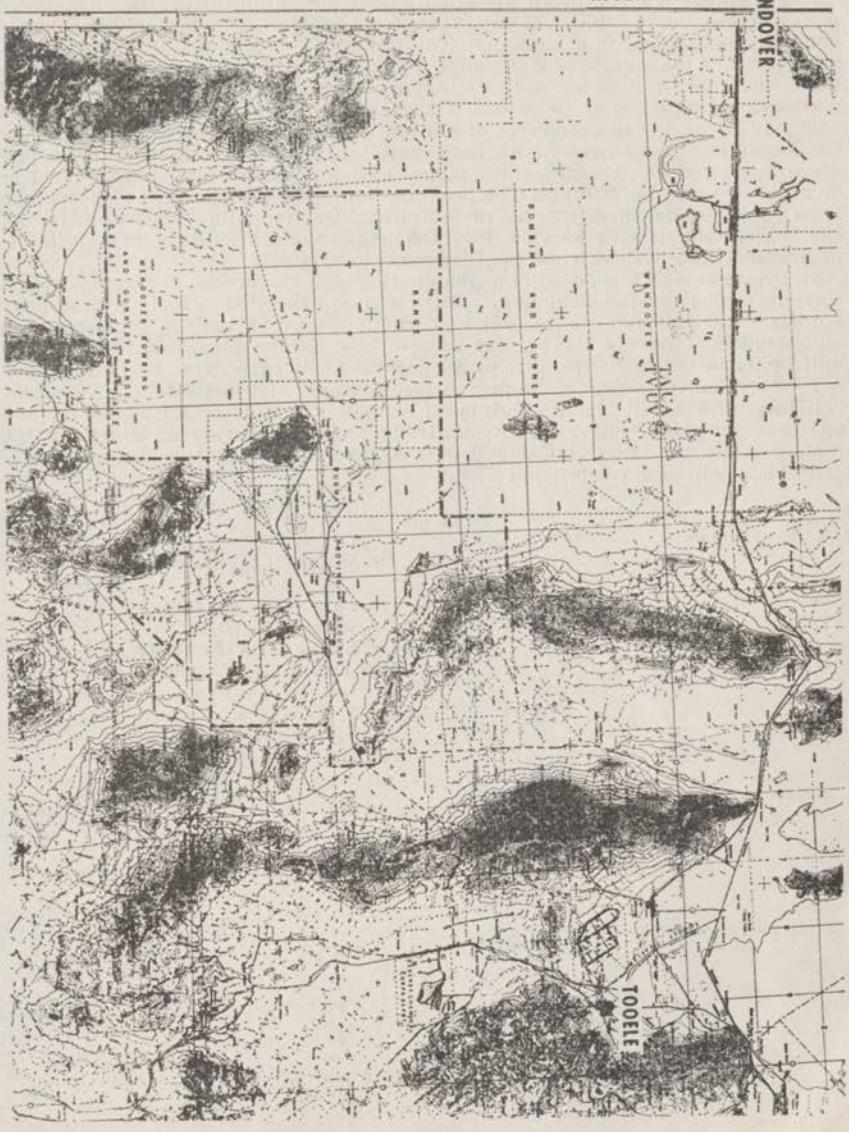
Dr. James B. DeWitt, assistant chief, Division of Pesticides Registration, Bureau of Sport Fisheries and Wildlife, U.S. Department of the Interior.
Dr. Warren C. Shaw, Assistant to Director, Corps Research Division, Agricultural Research Service, U.S. Department of Agriculture.
Dr. Louis C. LaMotte, Jr., Chief, Community Studies Section, Pesticides program, National Communicable Disease Center, U.S. Public Health Service.
Mr. David R. Waldron, Commissioner, Division of Animal Industry, Utah State Department of Agriculture.
Dr. Lester Machta, Director, Air Resources Laboratories, Environmental Science Services Administration, U.S. Department of Commerce.
Dr. J. H. Wills, Associate Director, Institute of Experimental Pathology and Toxicology, Albany Medical College of Union University, Albany, N.Y.
Col. Herschel E. Griffin, Chief, Preventive Medicine Division, Office of the U.S. Army Surgeon General.
Dr. G. D. Carlyle Thompson, Director of Health, Utah State Division of Health.

Mr. Howard M. Trussell, U.S. Army Materiel Command, executive secretary.

Consultants to the Committee

Dr. K. C. Emerson, Assistant for Research, Office of the Assistant Secretary Army (R. & D.).
Mr. Samuel Sass, Chief, Analytical Chemistry Department, Research Laboratory, Edgewood Arsenal.
Dr. Joseph Epstein, Chief, Defensive Research Department, Research Laboratory, Edgewood Arsenal.
Brig. Gen. W. W. Stone, Acting Deputy for Research and Laboratories, U.S. Army Materiel Command.
Col. Ralph Singer, Chief, Communicable Disease Branch, Preventive Medicine Division, Office of the U.S. Army Surgeon General.

APPENDIX A



APPENDIX B

SAFETY ANALYSES AND FIELD EVALUATIONS PROGRAM "SAFE" (SUMMARY)

A. Program SAFE was developed in response to recent events associated with the death of sheep in the area adjacent to Dugway Proving Ground. The program combines the continued investigation of the sheep deaths and includes a plan whereby the possibility of any future tests having effects beyond the Dugway boundary is reduced to a minimum. The program consolidates, in a single plan, all aspects of toxicology, ecology, meteorology, test technology, test area surveillance and control, disaster and evacuation control, public relations, and related matters bearing on safe operations. The plan, at present, covers a 5-year period (1969–1975) at an estimated cost of $14 million. The scope is broad and provides for flexibility. It addresses both immediate and long-range problems. The program is viewed as dynamic, and changes as required can be accommodated as dictated by scientific findings. The program developed incorporates recommendations by personnel investigating the sheep incident including representatives of the U.S. Public Health Service, U.S. Department of Agriculture, the Utah Department of Public Health and the Department of Defense.

B. Program SAFE represents a combination of both current and new projects. Current ecology and epidemiology efforts will be expanded to include toxicology studies with animals, plants, soil and ground water. From both the research and operations aspects, the present Deseret Test Center meteorological program will be increased and expedited to fill current knowledge gaps. Test technology will be expanded to provide improved test concepts and methodology. New surveillance efforts will include peripheral sampling to monitor the boundary and adjacent areas of Dugway Proving Ground and to provide an alarm in the remote event some material should pass beyond the reservation. Improved disaster plans will be developed and tested.

APPENDIX C

Concurrences:

Dr. WILLIAM H. STEWART,
Chairman.
Dr. JAMES B. DEWITT,
Dr. WARREN C. SHAW,
Dr. LOUIS C. LAMOTTE, Jr.,
Mr. DAVID R. WALDRON,
Dr. LESTER MACHTA,
Dr. J. H. WILLS,
Col. HERSCHEL E. GRIFFIN,
Dr. G. D. CARLYLE THOMPSON,
Mr. HOWARD M. TRUSSELL,
Executive Secretary.

Appendix 2.—"The Wind From Dugway," by Virginia Brodine, Peter P. Gaspar, and Albert J. Pallmann (From Environment Magazine, Vol. II, January–February 1969) [1]

Security is tight around the Army's Dugway Proving Ground. Restrictions are designed to keep out unauthorized persons and keep in the chemical and biological weapons tested at Dugway. But that security was breached one day last spring when a chemical agent got out of bounds. It carried sickness and death to the flocks of sheep grazing in nearby valleys. It told the world that something was wrong with the safety procedures that should protect living things outside the proving ground.

The Army is sufficiently confident of its knowledge of these weapons to manufacture and stockpile them, but it turned out that there were some things it didn't know about the movement of one of the chemical agents through the air and about its biological effects.

Dugway is in thinly populated Tooele County, Utah. The Great Salt Lake Desert covers the western half of the county, and in the eastern half is a series of small mountain ranges—Cedar, Stansbury-Onaqui and Oquirrh. The proving ground is at the edge of the desert, near the southern end of the Cedar Mountains and about 80 miles southwest of Salt Lake City. There are a few ranchhouses in the valleys, and the little town of Dugway, with a population of 3,000, is at the southern tip of the Cedar Mountains. The nearest substantial settlement is at Tooele, a town of 9,000 on the eastern side of Rush Valley. Highway 40 crosses the desert some 30 miles to the north of Dugway, and approaches Salt Lake City between the northern ends of the mountain ranges and the southern tip of Salt Lake.

Utah is still cold in the early spring, and a traveler on that route on the cloudy late afternoon of March 13 might have seen patches of snow at the side of the road. The Cedar Mountains, rising two to three thousand feet above the desert on the west and Skull Valley on the east, were snowcapped. No snow fell that day, but occasional rain showers began in the early afternoon.

At five that afternoon, work at Dugway was not yet over. Two tanks of VX had been loaded onto a plane, and the field test with this material was yet to be carried out. The V agents are less volatile substances of the same type as the "G" gases—the nerve gases—developed during World War II by Germany and later by the United States. That is, although they are sometimes referred to as "gases," the V agents, at normal temperatures, are liquids. Like the insecticides parathion, malathion, Azodrin and others, they are organophosphates. If a drop of a V agent falls on an exposed part of the body, it can penetrate the skin. Tiny drops suspended in air can be breathed in; clinging to food or forage, they can be taken by mouth.

Once in the body, these chemicals intervene rapidly in the processes of the central nervous system. They block the action of a natural chemical, cholinesterase, at the junction of nerves and muscles. When cholinesterase is blocked, there is a dangerous buildup of another chemical in the blood, acetylcholine. Acetylcholine normally conveys nerve signals to the muscles and viscera and then is inactivated by cholinesterase. When cholinesterase cannot do its work, nerve signals are not cut off as they should be and the muscles and viscera no longer function in a normal way. By disrupting the nervous system in this way, the V agent indirectly affects all the body's functions. Symptoms progress from respiratory troubles and loss of muscular coordination to excessive salivation, perspiration and involuntary elimination and finally to convulsions and death. If a victim is given the antidote atropine and artificial respiration immediately, he may recover. The lethal dose for humans has not been reported in the United States, but is known to be very small.

[1] Illustrations are in subcommittee files.

Mixed with VX in the Dugway tanks was a red dye to permit observers to see the otherwise colorless material and to photograph it. A third ingredient was a diluent which gave the final preparation a consistency similar to motor oil.

All those working on the test were doubtless wearing masks and protective clothing and were probably sheltered upwind of the target area. There have been some accidents at Dugway leading to exposures of the field crew and subsequently to tighter safety requirements.

There was apparently nothing particularly new or unusual about this test. Brig. Gen. William W. Stone, of the office of the Director of Research and Laboratories of the Army Material Command, later told the Utah congressional delegation that this chemical weapon had been tested literally hundreds of times since 1953, with more than 100 of these tests being spray trials. The March 13 test was the third of a series of three in an "operational test and evaluation program for an aircraft chemical spray system."

According to the Army Materiel Command, the plane took off, climbing only to 150 feet (about the height of a 15-story building). The pilot made two practice runs over the target grid, then, heading northwest, turned on the nozzles attached to the tanks and sprayed the target with 320 gallons of the chemical mixture. Five seconds later he ejected the tanks over a drop area. However, a story by Philip Boffey in the News and Comment Section of the December 21 issue of *Science* reports that there was a malfunction of the ejection equipment. One or both tanks failed to drop. The pilot had no way of halting the flow of the chemical and whatever remained in the tanks was therefore released at a higher altitude—according to Boffey—at about 1,500 feet. The *Science* account was read to Dr. G. D. Carlyle Thompson, Utah State Director of Health. He agreed that it was substantially correct.

Field test number three in the operational test and evaluation program was completed, and Dugway officers and men went to bed apparently without knowing that enough VX to cause trouble had slipped past the outer limits of the installation, had crossed the Cedar Mountains into all-too-appropriately named Skull Valley, and some had gone further still, across the Stansbury-Onaqui Mountains into Rush Valley.

Up and down these valleys, and on the lower slopes of the mountains, scattered flocks of sheep were grazing. As night fell, there were more showers, and the temperature, which had dropped suddenly in midafternoon, remained low.

On Wednesday, March 14, shepherds from the Hatch Ranch in Skull Valley noticed that some of the sheep near White Rock, on the eastern slope of the Cedar Mountains, were acting in a most peculiar fashion—dazed, staggering, jerking their necks spasmodically to the side, and finally dropping to the ground, apparently exhausted and unable to rise. During the day there were snow flurries, and the sheep continued to graze and lick the snow. More and more of them in two separate flocks showed the strange symptoms and by night some had died. On Thursday, the ranch foreman called the veterinarians who usually cared for the ranch's sheep, Dr. Marr Fawcett and Dr. Richard Winward. The veterinarians had never observed symptoms like this before and were unable to diagnose the illness or to help the sick animals. They called in Dr. Lynn James and Dr. Kent van Kampen, a U.S. Department of Agriculture veterinary pathologist, who arrived on the scene Sunday. Their diagnosis was that a chemical intoxicant was affecting the nervous systems of the sheep; they advised contacting Dugway for information about recent tests. Monday scientists from Dugway appeared, but they had no suggestions to make for the diagnosis of the illness or for therapy.

Several days later, sheep grazing farther from the test site began to sicken and die. A week after the test at Dugway a flock on the west side of the Onaqui Mountains began to show the now familiar, but still puzzling, symptoms.

The first story of what was described as a 'mysterious epidemic" appeared in the Desert News, a Salt Lake City paper, on March 19. By this time, men from the U.S. Department of Agriculture's Agricultural Research Service, from the Utah State Department of Health, from the University of Utah and from Dugway had examined the sheep and inspected the area. Dr. J. E. Rasmussen, veterinarian in charge of the Department of Agriculture's Animal Health Division, told the Salt Lake Tribune on March 20 that the sheep did not have a contagious disease, but were experiencing the effects of "some sort of poison." An insecticide or a poison plant were suggested as possible causes. As for a chemical weapon from Dugway, the same news story quoted a Dugway information officer: "When we first found

out about it, we checked and found we hadn't been running any tests that could cause this." A United Press International story which apeared the next day reported that Dugway officials assured the State Agricultural Commissioner's office "no tests which could be harmful to animals" had been conducted recently at Dugway.

Senator Frank Moss of Utah expressed concern and obtained from the Army Testing Command in Washington the first information about the spray test of a persistent chemical agent at Dugway on March 13. He released this information on March 21.

Meanwhile, toxic plants, pesticides, and viruses were eliminated one by one as possible causes. Laboratory tests were made on the tissues and blood of the sheep. Samples of the sheep's food, that had been eaten but not completely digested, were taken from the rumen and stomachs of dead sheep and also tested in the laboratory. The people who live in Skull Valley and those who had been working with the sheep were given blood cholinesterase tests; results were all within normal limits. Normal blood cholinesterase is within a range from 7.5 to 16.2; 40 people tested by the Utah Department of Health showed levels between 9.2 and 14.1. Lowered blood cholinesterase was found in sheep, however, and to a lesser extent in cattle and horses. Several days after the illness first appeared, sheep were treated with atropine, an antidote for organophosphate poisoning. The sheep failed to respond, except to massive doses, and even then the recovery was only temporary. Atropine was tried again, also unsuccessfully, in succeeding days.

Five sheep were taken into the test area on March 19. After grazing there, all five showed the same symptoms as the Skull Valley sheep, but all survived and recovered. Healthy sheep were placed in the Skull Valley pasture in early April. These, too, developed symptoms of central nervous system damage. Some sheep not seriously sick were sent to the U.S. Department of Agriculture's Research Station at Logan, Utah, for continued investigation. Among these were pregnant ewes, so that effects on the lambs could be observed.

Dugway personnel began to feed VX to healthy sheep on an experimental basis. Some of these sheep were then given atropine with better response than when these drugs were given to the range sheep after a timelag of a week or more.

General Stone explained at a hearing in the office of Senator Wallace F. Bennett of Utah on March 25 that prior to this experiment with feeding the V agent, there had been "meager information concerning its effects on sheep." In response to a later question from Environment, Joseph W. Penton, public information officer for the Army Materiel Command, stated on May 6 that previous tests of the agent had been on laboratory animals. Direct information about its effect on sheep was apparently not only meager, but nonexistent.

There were now nine agencies participating in the investigation: Dugway Proving Ground and Edgewood Arsenal from the U.S. Army, the Department of Health and the Department of Agriculture from the State of Utah, the National Animal Disease Laboratory and the Poisonous Plant Laboratory from the U.S. Department of Agriculture, the Department of Ecology and Epizoology from the University of Utah, the Department of Animal Science from the University of California at Davis, and the National Communicable Disease Center of the U.S. Public Health Service.

Only by testing the forage, the snow and the blood and stomach samples from the affected sheep for the presence of a chemical and comparing the results with the same tests of VX could it be determined whether VX was the cause of the disaster. But until 3 weeks after the incident only Dugway and Edgewood Arsenal, of the nine investigative agencies, had samples of the chemical weapon.

On April 4 a sample of the chemical weapon tested on March 13 was supplied to the National Communicable Disease Center (NCDC) in Atlanta Ga. NCDC was also given a sample of another chemical which, because of its similarity to VX, was sometimes used in Dugway tests. The sample provided by Dugway was small and dilute. The first laboratory tests were inconclusive. The NCDC chemists persisted, however, and on April 12 sent a telegram to Dr. G. D. Carlyle Thompson, director of the Division of Health of the Utah Department of Health and Welfare, which was released to the press. It said in part:

"Chemists of NCDC have isolated an identical compound from snow water and grass from White Rock area and from liver, blood, and stomach contents of dead sheep from the same area. * * * Compound has been shown identical to test agent supplied by Dr. K. M. Brauner, Dugway, April 4, 1968."

To chemists who were not involved in the investigation, one of the most puzzling aspects of the whole affair was the monthlong lag between the dispersion of

the agent on March 13 and its identification in animal and environmental samples on April 12.

Techniques for detecting minute amounts of chemical compounds are well known, and sensitive equipment is in use in many laboratories. The Dugway laboratory, in particular, where the composition of the test agent was known, where samples of it were available, and where sheep tissue samples were also available only a few days after the exposure, should have been the first to detect the similarities later found by the NCDC laboratory. Yet on March 29, 2 weeks after the first sheep deaths, a release from Senator Moss' office reported that General Stone, who was then heading the investigation in Utah "* * * said that none of the nerve agent which was released from the airplane on March 13 has been discovered in the soil, water, or forage of the area where the sheep died."

The need for techniques which would detect minute amounts of organic substances became acute some years ago, with the introduction of organophosphate pesticides. These chemicals are very efficient contact poisons with physiological properties similar to nerve gases. They are, however, much less persistent than pesticides like DDT. They are changed by contact with air, water, and sunlight, and therefore lose their toxicity rapidly once they are out in the environment.

Fortunately, our ability to isolate and detect infinitesimal amounts of such chemicals has improved vastly in the last dozen years. The detection of one chemical present in a mixture was often difficult in 1955 if it made up only one part in a hundred. Since the introduction of a new technique called gas chromatography, limits of detectability have rapidly decreased, first to one part in a thousand, then to one part in a hundred thousand. In the last 10 years it has become possible to detect as little as one part in a million or even, for certain mixtures, one part in a hundred million.

Gas chromatography is a process by which mixtures of gases, liquids, or solids in the form of vapors are separated. The mixture is swept through a tube in a carrier gas stream. The walls of the tube are coated with a stationary liquid, or the tube is packed with an inert substance with the consistency of sand which is coated with the stationary liquid. The components of the gaseous mixture are retarded in the tube differently, depending on their individual tendencies to be absorbed in the stationary liquid. A difference of seconds in the time each component is retained in the tube separates it from the rest of the components in the mixture and each component is swept out of the tube by the carrier gas individually. The time required for passage through the tube varies for different substances and is a distinctive characteristic of the substance. Although occasionally two substances may be retained for the same time, there are additional laboratory tests which can further differentiate them. Sensitivity depends on how little of a given substance can be detected in the carrier gas stream as it emerges from the tube.

Gas chromatography has replaced distillation as an analytical tool and has thereby revolutionized chemistry. Where distillation requires about one-thousandth of a liter and can separate substances with boiling points several degrees apart, gas chromatography can separate one ten-millionth of a liter of a mixture of substances with identical boiling points.

The identification of pesticide residues has become an important application of gas chromatography since it is necessary to determine whether the parts per million of pesticides which could be injurious if ingested by humans are present in fruits, vegetables, grains, or products manufactured therefrom.

An example of rapid analysis for traces of a pesticide occurred in the Tijuana bread tragedy of 1967, when hundreds of people were stricken and many died from eating foodstuffs contaminated with parathion, an organophosphate pesticide. Many more people would have died had not gas chromatography analysis in the California Department of Agriculture Pesticide Residue Laboratories rapidly identified the culprit, allowing doctors to halt the death toll by administration of atropine. Within 2 hours of the receipt of samples, and within 31 hours of the first death, chemists detected eight parts per million of parathion in a sample of contaminated bread and 19.5, 16.6, and 31.2 parts per million of parathion in the stomach contents of three victims.

The prompt identification of parathion as the poison responsible for the Tijuana tragedy contrasts sharply with the time required for the identification of VX as the poison which felled the sheep in Skull Valley. As early as March 24, an anonymous rancher told the Salt Lake Tribune that he had a laboratory report "confirming the presence of organic phosphate," while a Department of Defense

press release on April 18 stated that the agent tested was an organophosphate compound. Furthermore, the Dugway test agent was apparently similar in structure and ease of analysis to parathion. This was suggested by a report in Chemical Week on April 6 that paranitrophenol, which is also derived from the decomposition of parathion, had been isolated from the sheep and environmental samples.

All the nine agencies participating in the investigation presumably possess the chromatography equipment to do trace pesticide analysis. Why, then, was positive identification of the test agent in snow samples, grass, and sheep's blood and stomach contents delayed until early April when the NCDC obtained identical response from the Skull Valley samples, the test agent, and degradation products of the test agent?

Samples from the sheep and from the environment did not reach the NCDC until March 25, although the test agent was known to be chemically unstable and early information from the Army was that it would have a lifetime in the field of only 6 or 7 days. By the time the samples were taken the concentration of the agent was low.

No comparison between the Skull Valley samples and the authentic test agent was possible until April 4, when an apparently minute amount of test agent was supplied. Without virtually simultaneous comparison between suspected and authentic materials, positive identification by gas chromatography is very difficult. Once authentic material was available, identification by NCDC was quite rapid. It should be added that NCDC worked under the double handicap of no prior standardization of the analytical equipment for the test agent and a very small amount of test agent with which to work. The rapid identification of parathion in the Tijuana bread tragedy was possible only because the analytical instruments were constantly being checked and corrected for parathion identification. Constant recalibration of the instruments is important because the characteristic time required for the passage of a substance through the gas chromatograph varies with daily fluctuations in instrumental conditions.

VX is far more toxic than parathion, one of the most poisonous agricultural chemicals. A lethal dose for sheep is 20 milligrams of parathion per kilogram of body weight taken orally. After the experimental work with the sheep had been done at Dugway, the lethal dose of VX was determined: It took only a tiny fraction of a milligram of the nerve gas to kill the sheep exposed. Therefore, instruments of maximum sensitivity, designed specifically for phosphorus compounds; were required to detect the tiny, but lethal, amount present in the animals pastured in Skull Valley and in their environment.

The California Department of Agriculture laboratory in the Tijuana episode was using instruments which would easily detect one-tenth part of parathion per million parts of the sample. The NCDC laboratory in the sheep-kill episode had instruments which could probably detect one-hundredth part per million of parathion or materials similar to it such as the test agent. The Utah State Department of Health, according to its director, Dr. G. D. Carlyle Thompson, could have detected the agent in amounts only down to 10 parts per million. It had no phosphorus attachment for its detector at that time. The amount of the test agent reported by NCDC to be present in the Skull Valley samples was too little for the Utah State Health laboratory to detect. Even for its more sensitive equipment, the NCDC concentrated its samples before analysis so that the agent was less dilute and easier to identify.

It is not clear why the Dugway Proving Ground itself and the Edgewood Arsenal (the chemical warfare depot of the Army) lagged behind the NCDC in a relatively straightforward, albeit specialized analysis. It would be surprising if Dugway and Edgewood were not equipped to do the most up-to-date analyses for trace amounts of nerve agents. (Some of the other agencies whose laboratories may have had the capability to do so were not supplied with pure samples of the test agent.) A more important question is whether Dugway and nearby civilian health authorities are now equipped to do rapid analyses for any and all nerve agents which might be loosed in their midst, and whether they will be supplied with samples of materials being tested at the proving ground.

In order to effectively protect the populations for which they are responsible, health agencies must not only possess the sensitive analytical equipment, but they must also have access to the various agents which they might be called upon to detect. Further, monitoring for these agents must be continuous, or warning must be given when tests are to take place.

Environment was informed by Dr. Thompson that the Utah State Health Department now has the capability to detect one-tenth part per million of the test agent responsible for the sheep death.

There is a final puzzling aspect to the difficulties encountered in determining whether the test agent had indeed escaped from Dugway.

The mixture sprayed from the airplane at Dugway was mixed with a red dye. The extract of snow water from Dugway prepared at NCDC was found to have a red color. What this means is that the ratio of dye to nerve gas was sufficiently great that a crude test could have been done: shaking melted snow with a small amount of ether or some other organic solvent. The ether would extract the dye, thus concentrating it and making it easier to see. This would have given instant, albeit circumstantial evidence of the presence of the test agent. This crude test could have been done immediately after the observation of the first symptoms in the sheep. It could have been done in the field with no more equipment than a large jar and a campfire or ranch house stove. Furthermore, since the dye is persistent, its presence could have been sought by this method even after the nerve gas itself had begun to decompose. True, dye had also been mixed with a simulated agent which had been sprayed at Dugway, but this crude test would have indicated the presence of either VX, or the simulant or both, and this knowledge would have brought the investigation much closer to its goal.

Following the NCDC report on April 12, Dugway supplied the NCDC laboratory with additional samples of VX as well as samples of GB, another nerve gas. Further tests confirmed that the former was identical to material in the samples from sheep and from the Skull Valley environment.

The cause of the sheep-kill had now been found to the satisfaction of everyone but the Army, which continued to call the findings "inconclusive." But the answer to one question raised another: How could the spray from the test find its way across a mountain range—in fact, across two mountain ranges? The answer to this question is not to be found in the laboratory, but in the weather reports. Although there is a weather tower at the proving ground, detailed weather data obtained there on March 13 were not released. In answer to a question from "Environment" about meteorological conditions, a Dugway spokesman gave this summary:

"There was a wind from the south-southwest at the time of the March 13, 1968, test. The wind shifted about 2 hours later and blew from the west. There were scattered cumulus clouds in the general area at the time of the test and scattered rain showers developed during the early evening."

An analysis of the large-scale movements of the atmosphere based on data from other weather stations, especially from the nearby municipal airport at Salt Lake City, reinforces what is suggested in the brief paragraph from Dugway. "Weather conditions on March 13 were unfavorable for the atmospheric testing of a chemical weapon."

This is not simply hindsight. Weather indications on the preceding days and in the morning and early afternoon of the day of the test pointed to a distinct possibility that spray released at the proving ground might be drawn up into the clouds and released east of the mountains. Army statements have emphasized the wind shift which occurred 2 hours after the test, implying that it may have been an unexpected shift of wind that was responsible for the escape of the deadly chemical. However, any wind shift as long as 2 hours after the test may have been irrelevant. Droplets of the chemical had probably already been deposited in Skull Valley pastures by that time.

When droplets of a liquid are discharged from an airplane, they will disperse in a cone-shaped plume and gradually fall to the ground. How far the plume will extend, and how long it will take the droplets to fall depends upon the height at which they are discharged, the size of the drops and the speed of the wind. The smaller the drops, the more slowly they fall to the ground; the greater the wind speed, the faster and farther the drops will be carried. Although a uniform size of droplets may be desired, complete uniformity is impossible—and therefore exact prediction of size is difficult—because of the air turbulence around the spray nozzles in the wake of the airplane and the wind shear off the plane's wings.

Sprayed from a plane at a height of 150 feet, in a windy atmosphere as in the chemical weapons test of March 13, droplets down to a size of about 200 microns in diameter—that is, so small there would be 127 of them in an inch—would fall out within a few miles downwind from the spot at which they were

discharged. They would reach the ground in less than 3 minutes. Even droplets of half that size would not be carried much farther before reaching the ground. However, very tiny droplets, of 10 microns or so could be carried many miles.

But if there is turbulent air movement to carry the drops upward, the picture changes. Forest insecticide spray programs in mountainous areas often run into trouble with vertical eddy motions that interfere with the fallout of the drops and operate to pick them up and carry them a considerable distance from the point of discharge. As much as 25 percent of the amount sprayed has sometimes been lost in this way. If the ground has been warmed by the sun, there may be updrafts which pick up the droplets and carry them over even rather high ridges. Or, a cloud may draw the droplets up, hold them as it travels with the wind, and deposit them some distance away in a shower of rain. It was probably this mechanism which operated at Dugway on March 13. Even some of the spray released as low as 150 feet could have been drawn up into the clouds, while the probable accidental release as high as 1,500 feet makes this mechanism appear still more likely.

For several days prior to the test on the 13th, an intense low pressure system was approaching the North American continent from the west over the Pacific. By March 12, evidence was mounting that it would influence Utah weather in subsequent days. Cloudiness pertinent to the cold front of the system appeared over Nevada and northwestern Utah. On the 13th, this maritime cold front passed through Utah. As is well known, a front passage is often accompanied by wind shift, gustiness, increased cloudiness, temperature changes and precipitation, and all these occurred and were observed at the U.S. Weather Bureau station in Salt Lake City. A cold front passage disrupts the stratification of the atmosphere and vertical air movements develop, with small parcels of air moving upward and downward almost independently of each other. Cumulus clouds, with flat bases and rounded outlines may be formed, and sometimes (as in this case) there is a cumulonimbus formation—a mountainous cumulus cloud extending to great heights and topped with a veil of ice crystals.

At the U.S. Weather Bureau station at the municipal airport in Salt Lake City, an apparent front passage was noted just before 1 o'clock in the afternoon of March 13, with the wind shifting from the south-southwest (190°) to the west (270°) and changing from 14 to 15 miles per hour with gusts up to 23. At 3:15 there was a 7 degree drop in temperature to 42° F. The cloud ceiling lowered from 5,500 feet to 1,900 feet, and there were rain showers in the area. The surface winds continued to shift in the late afternoon from north-northeast to west and back to northwest, but higher up, where the clouds were, the wind was steadily from the southwest at a speed of 29 miles per hour and more. Occasional rain showers were observed southwest of the station just before 5 and again 2 hours later, with scattered cumulus clouds throughout the day and evening. There were heavy cumulus clouds in all directions between 5 and 6 o'clock, including the southwest, the direction of Dugway. A closer look at the 5 o'clock weather picture is presented in the illustration on page 9.

In the jet stream high above the earth, a core of high-speed wind was measured over Northern California and Oregon on March 12, shifting southeastward toward Utah. At 5 o'clock on the 13th, the maximum wind speed of this core was measured near Salt Lake City. Wind was recorded from the southwest (235°) at a height of 33,000 feet and a speed of 115 miles per hour. It appears, therefore, that this wind passed over Dugway earlier in the afternoon. The consequence of such a passage of high speed jet wind is an intense interference with the dynamics of the weather layers below.

From the combined effects of the cold front and the jet stream wind, increased vertical mixing of the atmosphere below could be expected, favoring the development of precipitating cumulus clouds. Such a cloud could suck particulates such as the oily droplets sprayed at Dugway into its updraft. If their size was less than 250 microns, they could be drawn into the interior of the cloud at a velocity of 1 meter (39.37 inches) per second. In exceptional cases, eddies of turbulence near the earth's surface produce vertical speeds of 2 meters per second. When this occurs, particulates up to 500 microns can be carried into the cloud. The cloud would hold these particles until it started to precipitate.

A surface wind from the northwest would have moved the spray particles southeast as they were being drawn up into the cloud. The cloud would then have been blown northeast by the wind in the upper weather layers. This is consistent with the position of the affected flocks, and is indicated on the map.

It is not unlikely that such a cloud would travel a distance of about 30 miles before precipitation began. A shower would then deposit much of the chemical agent in the cloud along with the rain. However, the smaller spray droplets might well be kept in the upper part of the cloud even after the first precipitation. Such a remainder could be forced to precipitate later, when the cloud traveled over another mountain ridge, where the upslope motion from below would stimulate coalescence among the cloud elements which would fall as rain on the other side of the mountain. This could readily explain the spotty deposition of the chemical in Skull Valley and beyond the next ridge in Rush Valley. It also suggests that the town of Dugway, which is in the sector probably traversed by the clouds, may have had a narrow escape.

Cumulus cloud formation, with southwest or west winds, falling temperature, and precipitation could have been expected from the large-scale weather developments and strongly indicated against dissemination of a persistent lethal agent on that day.

Still another question relates to the monitoring of the spray plume. Recently, the U.S. Forest Service, in cooperation with the Stanford Research Institute, has employed an improved technique for monitoring plumes from insecticide spraying. Taking advantage of developments in laser technology, lidar rays have overcome many of the difficulties in tracking spray plumes. The lidar gun shoots a beam of light into the plume. The reflected beam is measured on an instrument that registers variations of light in electric current and records them photographically. The lidars used by the Forest Service are able to track tiny droplets for as long as 20 minutes after they are released. Lidar is certainly available to Dugway, and if used during the March 13 test, would have revealed the escape of the spray northeast toward Skull Valley. Lidar can be used even after dark. But even if some other photographic monitoring process had been used rather than lidar, there should have been ample light to follow the spray, since the sun did not set till 6:30.

Environment asked R. L. McNamara, the Chief of Dugway's Information Office, what technique the Army used to monitor the amount of material reaching the ground and how long the monitoring was continued. The reply was that this is "defense information not releasable to the public."

Ten months ago, when the sheep-kill was in the news, concern for improved safety measures around Dugway was repeatedly expressed by Senators Moss and Bennett of Utah, by other public figures and by people in the area. A Federal Interagency Advisory Committee was formed to review "the procedures, talents, monitoring equipment facilities and safety regulations" at Dugway. The committee's report, released on December 20, made sweeping recommendations for changes in safety procedures. In doing so, they revealed quite clearly the deficiencies that existed last spring. Indeed, given the state of safety precautions revealed by the report, it can only be concluded that the people of Utah, and perhaps of neighboring States as well, were fortunate that the accident was no worse, and involved only sheep, not people.

The committee's first recommendation was that persistent lethal agents should not be tested in amounts exceeding one artillery round, rocket or mine without modifications of safety procedure. Two tanks—320 gallons—of VX is far more than this, and it may be that even greater amounts were dispersed in other Dugway tests.

The committee felt that past procedures were adequate for continued testing of agents and munitions for riot control, for those that are incapacitating rather than lethal, and for those that are lethal but nonpersistent. A fourth category, "new and/or more toxic agents and munitions" was not discussed. The changes in safety procedures required for the resumption of tests of persistent lethal agents and munitions (such as VX) took up most of the Advisory Committee's attention in its report.

No release, the report advises, should be made at heights greater than 300 feet; no significant fraction of the agent cloud should be composed of particles smaller than 100 microns in size; and positive control of agent dissemination should be maintained by automatic flow devices. Also, when high performance aircraft are used for dispensing toxic chemical agents having properties equivalent to those of the nerve agent VX, control by radar and radio, by the establishment of limitations on total quantity of agent dispersed and by other available means, is recommended.

On March 13, part of the release was probably as high as 1,500 feet. Smaller particles, as stated earlier, fall to the ground more slowly and are more easily

picked up by vertical drafts of air; it was probably these smaller particles which traveled across the mountain. Positive control of agent dissemination means that the pilot should be able to shut off the dissemination promptly if anything goes wrong. This was apparently not possible on March 13.

The advisory report's discussion of weather conditions states that heretofore the presence of turbulent winds, which would mix and dilute any of the agent not falling rapidly to the ground, was considered a desirable weather condition for a test. The other problems of turbulent winds, namely, changing wind directions, updraft into clouds, and rapid transport of these clouds beyond the proving ground, were apparently given little, if any weight. Moreover, concern with wind and weather was restricted to a few miles from the release.

These changes in procedure having to do with meteorological conditions were recommended: Winds should be from the south-southeast blowing toward the salt flats where little vegetation, no domestic animals and no people would be exposed until Highway 40 is reached. The wind at the surface should be no more than 15 miles per hour, and the agent cloud should not cross Highway 40 for at least 3 hours. Confidence in the weather forecast should be high; there must be past experience demonstrating the reliability of predictions from similar weather situations. Concern must now be extended to several tens of miles. No thunderstorms should be present within 100 miles of the test site at release time nor predicted to occur within 100 miles of the cloud trajectory for at least 8 hours from actual release time.

The discussion of weather earlier in this article makes the need for most of these recommendations quite clear, but a few words should be added about the danger from thunderstorms. When thunderstorms are imminent, updrafts into the clouds are very strong. Quite large particles can be drawn up from low altitudes and carried tens of miles before being dumped in a thundershower. Moreover, thunderclouds may grow to towering heights and travel at great speeds; smaller particles could be held in the upper portions of the thunderclouds and carried still farther. A test of VX, or some other persistent lethal chemical, was apparently quite possible in such weather under the old procedures. With or without a malfunction of the tanks and a high release of the agent, a deadly load might have been picked up and carried the 80 miles to Salt Lake City.

The surface winds referred to in the advisory committee report are those that can be measured with an anomometer—a device attached to a pole which measures wind direction and speed from 10 to 30 feet from the ground. This seems to imply that radiosonde soundings from balloons are not taken prior to tests—that perhaps, indeed, the weather station at Dugway was not even equipped to make these soundings, which can give wind direction and speed up to great heights. The committee recommends "improved meteorological capability" but does not spell this out in detail. This capability should certainly include radiosonde soundings at the proving ground or close coordination with the Salt Lake City weather station, which takes these soundings on a regular basis.

HOW THE SHEEP-KILL COULD HAVE BEEN AVOIDED

If weather conditions had been properly evaluated, there would have been no atmospheric test of VX on March 13.

If, in spite of unfavorable weather, spray testing was done, proper control of the spray equipment could have prevented release above 150 feet off the ground, lessening, though not necessarily eliminating, the possibility of escape of VX outside the proving ground.

If the spray did drift off the proving ground, or was drawn up into the clouds, monitoring of the spray plume should have indicated this. Ranchers to the east and northeast of Dugway could then have been notified to move animals out of the nearby pastures and put them on stored food and uncontaminated water.

Had the on-site monitoring failed to indicate the escape of VX, off-site monitoring—a simple test of rain and snow water in the vicinity of Dugway on March 14 for the presence of the dye that had been mixed with VX—could have indicated the probable presence of the chemical weapon. Some of the sheep might have been saved by removal from the contaminated pasture and treatment for organophosphate poisoning.

Had none of these steps been taken, the first sign of central nervous system damage in the sheep should have indicated the possibility of VX poisoning. Again,

removal from the pasture and treatment with atropine and 2–PAM might have saved some of the sheep. Prompt laboratory investigation of samples of snow water and forage from the pasture, and stomach and rumen contents from the sheep could have confirmed the diagnosis.

Better understanding of what can happen to drops of VX and like materials under various weather conditions is also recommended, but not spelled out in detail. One way this can be achieved is by spraying a harmless material in the same diluent used for chemical agents in a variety of winds and weathers and monitoring the spray closely; planes could be sent aloft to see if any of the material could be picked up at various heights, as is done with fallout from nuclear weapons tests. Planes with continuously recording photospectrometers are used for air pollution monitoring in California.

The committee also points out that the death of the sheep suggested the possibility that scavenging of the air by rain or snow may be a crucial contributor to hazard from the dispersal of chemical agents in the atmosphere, and advised testing only when confident predictions can be made that there will be no precipitation for 8 hours after the test.

A very much more extensive and intensive research program is recommended, beginning with determination (or estimation) of the toxicity to animals and humans of both sexes and all ages and to pregnant females of any compound released into the environment. This should be studied by single and repeated doses, and by low-dose chronic administration. The committee stated that on June 14, 1968, the values for the LD_{50}, that is, the amount of the agent that would kill half those exposed, was available for the mouse, rat, guinea pig, rabbit, cat, dog, monkey, and chimpanzee among laboratory and pet animals and for the pig, goat, and horse among domestic animals. No information was available on the sheep, the most important domestic animal in the vicinity, nor on the cow, nor on any of the wild species living in that area.

Research was recommended on the fate of the agents in the environment, in the soil, plants, water supplies, snow and indigenous plants at the test site and up to several tens of miles away. The kind of study needed is outlined in some detail. The report then remarks that "the greater the risk of the agent reaching off-post locations [inhabited by man, domestic animals and wildlife] the greater the need and the degree of understanding of the behavior and fate of the agent in the environment." While this is true, it leaves a somewhat disquieting loophole in the research recommendations. In March, Dugway officials stated unequivocally that there was no risk of the agent reaching any off-post location. If the need for environmental research is to be determined by Dugway estimates of the likelihood of off-post exposures, the sheep-kill incident can give the people in the surrounding area little confidence that this research program will be pursued with vigor.

The sheep-kill incident showed that on-post monitoring of chemical agents was inadequate and off-post monitoring was nonexistent. There was no alarm system, and no medical countermeasures for man or animals were prepared. The committee gave some pages of its report to the "need to develop and implement a monitoring program designed to detect the immediate presence and/or verify the absence of chemical agents in areas outside the Dugway Proving Ground grid areas, including the off-post areas contiguous to the proving ground."

The committee recommended 10 permanent monitoring sites of about 5 acres each, three of them west of the Cedar Mountains, five east of the Cedar Mountains in Skull Valley, and two east of the Stansbury Mountains in Rush Valley. It would seem that in addition, and especially if the committee's recommendations to test only when the wind is from the south-southeast is followed, there should be at least one station between Dugway and Highway 40. The committee proposed that the monitoring system be developed in coordination with the Utah State Department of Health and other appropriate State and Federal agencies.

Monitoring as outlined by the committee would have three aspects: regular sampling schedule (at least monthly) to determine the presence or absence of the agent chemicals in soil, water, snow, and plants; a "sentinel" system using sheep, since they have proved to be susceptible to at least one of the chemical agents tested at Dugway, or, when the sensitivity of indigenous wild animals has been determined, using one of these species; and an alarm system based on an air sampler which automatically tests for the chemical agents. However, the committee warns, the lack of sensitivity of the air sampler may limit its usefulness.

Three types of monitoring not mentioned by the committee could well be added: the use of treated cards which are sensitive either to the agent itself or to the oily carrier, as used with good results to monitor forest spraying programs; use of dye, with a specific color being limited to a specific agent, and environmental sampling for the presence of the dye imediately after every test; and the addition of flourescent particles to the oil carrier. When flourescent particles are used, vegetation can be quickly checked by placing it in a dark box equipped with an ultraviolent light. This equipment is easily portable and can be carried on a small truck. The U.S. Forest Service has used this method for detecting drops as small as 26 microns.

The committee found Dugway's routine safety measures on the post adequate, but recommended coordination with the off-post medical community, State and Federal health authorities, and agricultural agencies concerned with animal health. Also recommended were preparations for that "accidental event which might occur only one time every 25 years," which might expose "groups of personnel not involved with testing who live on Dugway Providing Ground or in areas surrounding the test installations." These recommended preparations include: a mass casualty plan with specific care and evacuation procedures for patients exposed to chemical agents, liaison and coordination with outside medical resources to insure a feasible medical evacuation, and at least annual exercises to test mass casualty and medical evacuation procedures.

In order that the surrounding community may have confidence that testing is being done safely, and so that in the event of an emergency, animals and people may have some protection, the committee stated that general knowledge of Dugway activities, of the characteristics of the agents being tested, and of the safety precautions on and off the post must be communicated to certain responsible state officials. In addition, some officials must have specific technical knowledge. A review by the Department of the Army of the present public information policy was also recommended "for possible provision of information before, during, and after testing concerning the general nature of the tests and the comprehensive safety program associated with the tests."

Finally, the report concluded with a recommendation for a permanent chemical safety committee to provide at least annual review and advise the commanding general at Dugway, and a suggestion that possibly the Army should manage additional land adjacent to the proving ground.

The Army has announced that all the recommendations of the committee have been adopted.

Improved safety precautions may insure that the same disaster is not repeated, but a larger problem was illuminated when the sheep died. Chemical and biological weapons cannot be used in war without extensive testing under various meteorological and field conditions; without such testing the military will not know the capabilities of the weapons and there is also danger of backfire on the users. Yet field testing, which releases these agents into the environment, where to some extent they may escape from control, is itself hazardous.

One simple mistake in chemical or biological testing can have far-reaching consequences. Dugway officials will now be alert to prevent a recurrence of the particular accident of last March, but a test plane may crash someday, some chemical agent other than VX whose environmental or biological behavior is not fully understood, some other imperfectly assessed meteorological conditions, some malfunction in a dispersion system or trial of an untried system, some other human error may cause some other accident. Next time, the consequences may not be limited to sheep.

NOTES

A technical supplement to this article, "Study of Weather Development and Meteorological Meso-scale Conditions in the Area Southwest of Salt Lake City, Utah, during Mar. 10–14, 1968," by Albert J. Pallmann is available on request from "Environment."

Mrs. Milton Meux, an "Environment" reader in Salt Lake City, provided us with complete clippings of the local news reports on the sheep-kill incident. Her help is gratefully acknowledged.

P. 6. "* * * supplied to the National Communicable Disease Center" and material that follows on NCDC testing from Investigation of Sheep Deaths—Skull Valley, Utah, Department of Health, Education, and Welfare, Health Services and Mental Health Administration, DP, National Communicable Disease Center, Atlanta, Ga., Apr. 29, 1968.

P. 42. "The Committee's report * * *." Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground, Department of the Army, Washington, D.C., November 1968.

Appendix 3.—Statement of Brig. Gen. William W. Stone, Office Director, Research and Laboratories, U.S. Army Materiel Command, Washington, D.C., March 25, 1968; and Press Releases From Office of Senator Frank E. Moss of Utah, Concerning the March 13, 1968, Sheep-Kill

Gentlemen, we are here today to answer the specific questions that you have raised concerning the recent death of sheep near Dugway Proving Ground. After covering these questions I would like to present to you on a chart our current knowledge of what has happened. As you will see we do not yet know whether or not Dugway tests were responsible for the death of the sheep.

The agent with which we are working is a persistent nerve agent.

I imagine several of the you have seen the editorial that appeared in the "Deseret News" on March 23. Within its objective review of the situation it quoted a 1959 House committee report which states very well the importance of the work that is being done:

"The best immediate guarantee the United States can possess to insure that CBR is not used anywhere against the free world is to have a strong capability in this field too."

Moving now to your specific questions:

1. *Purpose of test.*—The Dugway test of March 13, 1968, was part of an operational test and evaluation program for an aircraft chemical spray system. The test was the third one of a series of three. A persistent chemical nerve agent was sprayed from tanks. The spray mission was flown by a high performance aircraft at low level. The objectives of the program were completely routine tests applied in all materiel research development activities. One objective of such tests is verifying operating instructions and safety procedures.

2. *Who was flying the aircraft.*—An Air Force pilot.

3. *Name of person in charge of test.*—Col. James H. Watts, commanding officer, Dugway Proving Ground.

4. *Type of aircraft used.*—A high performance aircraft.

5. *Speed, altitude, and direction of aircraft.*—The speed of the aircraft cannot be released. The altitude was 150 feet above the ground. Heading 315 degrees.

6. *Name of agent used.*—A persistent chemical nerve agent.

7. *Known effects of agent on sheep, other animals, and man.*—The agent in question has been studied extensively in many types of animals and a great deal is known about its effect on humans. There is meager information available concerning its effect on sheep. During the past week tests have been conducted at Dugway Proving Ground in which the compound was fed in varying amounts to a control group of sheep. The signs exhibited by sheep in these tests were similar to those seen in other animal species which have been studied.

8. *Has agent been used before in test.*—For more than 10 years the agent used has been released at Dugway literally hundreds of times. A large number of these trials have been spray trials using aircraft.

The largest single spray program was a World War II effort involving mustard in which tons were released from spray tanks very similar mechanically to the tanks used in this test.

Spray testing with nonpersistent nerve agents was initiated in 1953. Over a period of years in excess of 100 spray trials were successfully conducted. There were accidental field crew exposures on occasion. None of these incidents were serious but they did cause redefined safety requirements, increasing the safety factors associated with testing.

The point is that the persistent agent involved in these tests was nonvolatile. The persistent agent is characteristically much less volatile. These tests are discussed further under question 14, below.

9. Amount of agent, et cetera.—320 gallons were released. The pressure involved in release was approximately 6.5 pounds per square inch. The area covered cannot be released.

10. What checks were made on position of aircraft (ground observation, radar, instruments, or known landmarks). The flight pattern to be flown was fully discussed with the pilot and radio communications were maintained between the pilot and test officer throughout the flight. Established procedure followed on this trial was to mark the flight line with burning smokepots placed approximately one-half mile off the grid. Two dry runs were made prior to the agent dissemination run to insure that the pilot was familiar with the area and flying at the proper altitude. This was verified by ground observers backed by photo crews observing the runs through their instruments. After the dry runs were made to ascertain that the proper flight pattern and countdown to release had been established, the pilot was informed to come in on the dissemination run. During this run, data were collected which can establish position of the aircraft at any point on the dissemination run to 1 meter accuracy from information obtained with three Contraves Photo Cine theodolites placed at positions surveyed to first order accuracy (1 in 100,000). The pilot monitored altitude and airspeed with reference to flight instruments and flew the desired flight path with reference to the smoke and ground landmarks.

11. Weather conditions at time of test.—Scattered low and middle clouds with a high, thin overcast was observed for the time of function at near Granite Peak and at Wig Mountain. Low scattered clouds were observed for the spray trial over the Salt Flats. A weak front was in the area. Frontal passage was not well defined. The low-pressure area associated with the front during the morning hours had remained stationary and was centered in east-central Navada by late afternoon.

12. Land conditions at time of test.—The ground condition was dry on all the grids at test time. The valleys and the lower elevations in the mountains were also dry. There was some snow cover at the higher elevations in the mountains.

13. Winds aloft, direction, velocity, and gusts at time of test.—The winds aloft from the surface to 2,300 feet were generally southwest, 5 to 25 miles per hour, with gusts to about 35 miles per hour. The observed data in the target area are as follows:

Height	Wind direction (degrees)	Speed (m.p.h.)
6 feet	209	14.2
100 feet	214	22.7
150 feet	210	19.4
250 feet	218	20.8
480 feet	208	16.6
1,030 feet	211	23.9
2,290 feet	238	20.0

14. Have aircraft tests been conducted before and, if so, what were the results?—As noted above, the answer is yes. Aircraft spray is a particularly effective way of employing chemicals whether the chemical be a smoke screen, a riot control agent, or a lethal chemical. Dugway's largest spray programs were the mustard programs of World War II. Nerve agents have been tested in aircraft spray systems extensively, beginning in 1953 and continuing at the present time.

Such tests follow a strict procedure. First, trials are conducted using nontoxic materials with physical characteristics similar to the agent later to be tested at Dugway. This is done to evaluate system performance. The critical

factor is the size of the droplets produced, since a droplet falls at a rate depending on its mass. The nontoxic material is used in trial runs to define the safe operational limits for the agent trials. To give some examples, on one of Dugway's spray programs in 1961, eight simulant trials were conducted and completely evaluated before running the two agent releases that completed that particular program. Two months of analysis separated the simulant trials from the spray missions using the actual agent. In another program, seven simulant trials preceded the three agent missions. Again, several weeks of study intervened. On the first major nerve agent spray evaluation conducted in 1962, 21 simulant trials preceded three agent missions. The point being that rather elaborate evaluations are routinely conducted before authorization to fly a toxic spray mission is granted. The current program is noteworthy in that respect.

Preliminary trials included one test with water-filled tanks and seven tests with a simulant. Two single tank trials and one two-tank trial had been conducted with simulants before the first agent trial was conducted.

The results of these trials fill voluminous test reports and in line with the present problem, to date there has been no evidence that toxic clouds ever escaped the confines of the proving ground. It is worth noting that the inhabited area lying nearest to Dugway's testing sites houses the wives and children of the scientists conducting Dugway's tests. That fact provides an insight into Dugway's safety policy that might be overlooked in a detailed review of volumes of test reports.

15. Antidotes against poisoning produced by organophosphates.—Atropine or atropine plus oximes are generally beneficial as antidotes against poisoning produced by VX and against many but not all other anticholinesterase poisons. Atropine is routinely given by veterinarians for poisoning produced by organophosphorus compounds in farm animals.

No quantitative data are available on the value of atropine or any other antidote against poisoning produced in sheep by the VX, especially when the poison has been given over a prolonged time period.

16. Safeguards used to avoid human contact with agent at Dugway.—The spray tanks used on the subject test were factory filled, sealed, and delivered to Dugway in approved shipping containers with technical escort and were free of contamination. Handling of the tanks prior to test was performed in normal work clothing. For the handling of those test items that are filled with toxic agents at Dugway, more extensive protective measures are normal. These include the wearing of butyl rubber clothing, boots, gloves, gas masks, and head hoods. When personnel are operating in grid areas which are contaminated, the same complete protective clothing is worn. All equipment (including vehicles) used on our contaminated grids is considered to be permanently contaminated and is kept in the test area. Access to this area is controlled by a security guard. Personnel are logged in and out so their location is known. During the conduct of an operation an assigned safety officer identifies and controls the location of all test personnel through radio and direct contact. He assures that all personnel are in safe positions with respect to toxic cloud travel, that is, safe downwind distances and upwind locations.

Gentlemen, up to this point we have given you the best answers we have to the 16 specific questions you asked. With your permission I would like now to present on a summary chart the situation as we now see it. In the open sheep symbols we show the location of the sheep herds which have been affected. The losses range from essentially the entire herds at White Rock and the Hatch herd here to about 100 sheep at Hatch Ranch and 10 sheep in a herd in Rush Valley. We do not know how many sheep have actually died; however, we should get a good count as the burial operation proceeds. This operation should start today, Monday.

The solid sheep symbols show the location of large herds which are completely unaffected. Also in the northern part of Skull Valley there are other small herds unaffected. The blocks show the general areas in which we have taken samples.

In these areas we have taken, and are still taking, hunderds of samples of soil, water, snow, and vegetation looking for traces of the agent we were testing. Outside the general area of the test grid itself, we have found no traces whatsoever of our agent. This is a typical finding and much like what we see in our normal safety surveys which we do routinely, although at a much smaller scale, as part of our safety program.

In the areas where the largest sheep-kills have occurred we and others have found some depression of the cholinesterase level in both live and dead sheep and also in some cattle. This observation is to be expected in any animal or human exposed to an organophosphorus compound. Compounds of this type also include a number of insecticides. Here too we do not at this point have any evidence that insecticides have been used in the affected area.

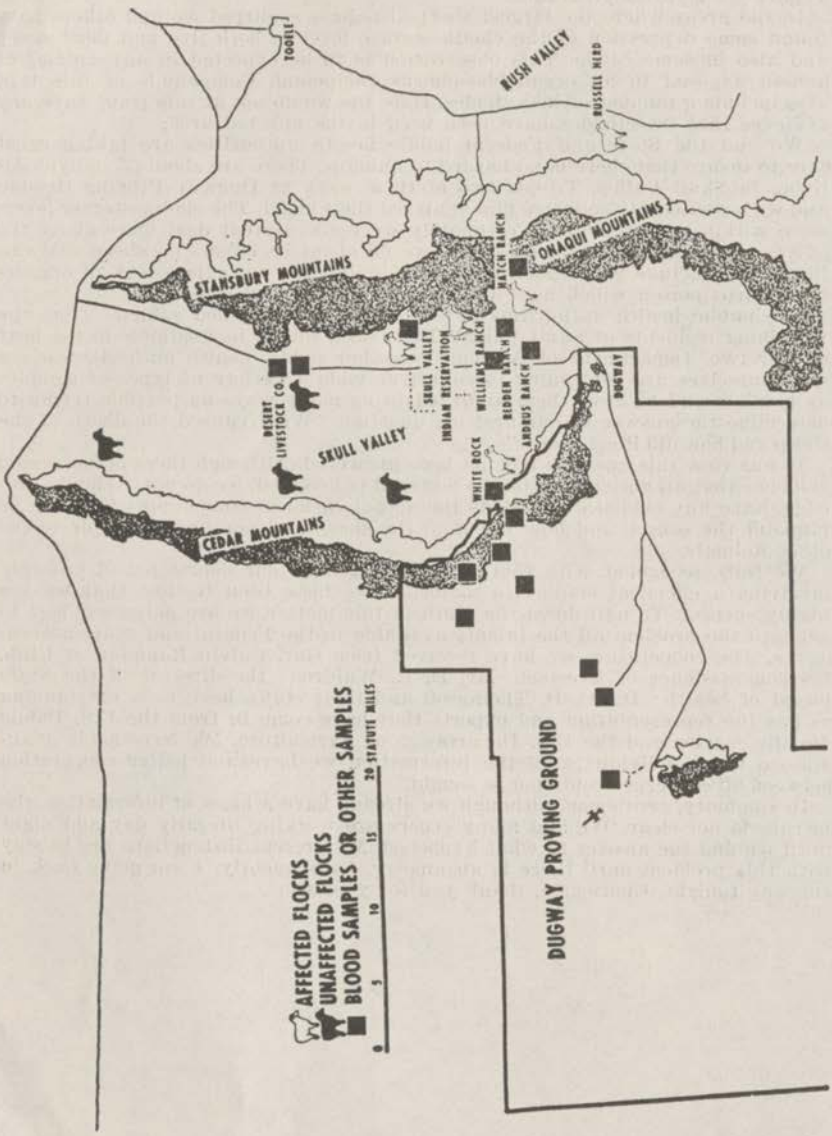
We and the State and Federal public health authorities are taking great care to insure that there is no hazard to humans. There are about 55 individuals living in Skull Valley. Twenty-two of them work at Dugway Proving Ground and we have already collected and analyzed their blood. The cholinesterase levels were within normal limits. Fortunately we know a great deal more about the effects of this agent on humans than we do about its effects on sheep. We can therefore conclude with that these individuals were not exposed to an organophosphorus poison which may have caused the sheep deaths.

The public health authorities have started to take blood samples from the remaining residents of Skull Valley. Their data should be available in the next day or two. Department of Agriculture, other public health authorities along with ourselves are continuing to collect as wide a variety of types of samples as possible and to have them analyzed in as many ways as possible trying to determine the answer to our first big question, "What caused the death of the sheep and how did it get there?"

In our view this question has not been answered. Although there is increasing evidence that an anticholinesterase material is involved, we do not, to my knowledge, have any evidence to tell us the actual chemical compound or to help us pinpoint the source and how it got to the sheep and not to humans or to the other animals.

We fully recognize, with this occurring right on our doorstep and probably involving a chemical similar to materials we have been testing, that we are highly suspect. To nail down the truth in this matter we are doing our best to get into the problem all the talents available in the Federal and State governments. The cooperation we have received from Gov. Calvin Rampton of Utah, his commissioner of livestock, Mr. D. R. Waldron; the director of the State board of health; Dr. C. D. Thompson and their staffs have been outstanding as has the representation and experts that have come in from the U.S. Public Health Service and the U.S. Department of Agriculture. We have made available to these individuals all the information we have and better cooperation between all concerned could not be sought.

In summary, gentlemen, although we already have a mass of information, the picture is not clear. We and many others are working literally day and night until we find the answer to what happened. My present instructions are to stay with this problem until there is an answer. Consequently, I am going back to Dugway tonight. Gentlemen, thank you for your time.


TOOELE
RUSH VALLEY
RUSSELL HERD
STANSBURY MOUNTAINS
ONAQUI MOUNTAINS
MATCH RANCH
SKULL VALLEY
INDIAN RESERVATION
WILLIAMS RANCH
BIDDEN RANCH
LABRUS RANCH
DESERT LIVESTOCK CO.
SKULL VALLEY
WHITE ROCK
DUGWAY
CEDAR MOUNTAINS
DUGWAY PROVING GROUND
AFFECTED FLOCKS
UNAFFECTED FLOCKS
BLOOD SAMPLES OR OTHER SAMPLES
0 5 10 15 20 STATUTE MILES

[News release from Senator Frank E. Moss]

MOSS CONVINCED ARMY TEST CAUSED DEATHS OF SHEEP NEAR DUGWAY PROVING GROUND

WASHINGTON, D.C.—Senator Frank E. Moss today said he was personally convinced that the Army tests of nerve agent conducted on March 13 at Dugway Proving Ground had resulted in the deaths of some 6,400 sheep nearby.

The Senator listed several reasons for stating this conviction.

1. The Army has admitted they conducted the test and that the wind direction was in the direction which would have affected the sheep.

2. The next day, severe winds, gusts, and twisters blew snow and dust throughout the Dugway and Skull Valley Area.

3. The sheep died from a central nervous system disorder which the Army has said their nerve agent would cause.

4. Tests of all Government agencies have failed to determine any alternative to the Army nerve agent as the cause. Poisonous plants, disease, pesticides, and insecticides have all been ruled out by the Department of Agriculture.

5. Five sheep taken into the test zone on March 19 all suffered the same symptoms as the sheep in Skull Valley.

"These facts and others have convinced me that the Army test caused the death of the sheep," Senator Moss said.

"I can appreciate the Army's reluctance to admit their guilt in this matter, but by their own admission, all the evidence points to that conclusion. I realize the scientific tests will take some time to complete, but I feel the preponderance of the evidence is very well established to show the Army test was the cause of the sheep loss.

"I call upon the Army to make public assurances that their testing techniques will be studied and their safety efforts will be redoubled in the future to avoid any such events happening again. I would expect them especially to tighten weather conditions criteria for future tests."

The Senator met with officials of the Public Health Service and the Department of Agriculture today and was again assured that no humans had been discovered in any of the examinations who had been affected by the nerve agent used in the test.

"In spite of published reports to the contrary, I am satisfied that no human was affected by the test," Senator Moss said. "But this is an example of the rumors that will continue to circulate until the Army gives all the facts and puts this whole case to rest."

APRIL 1, 1968.

[News release from Senator Frank E. Moss]

ARMY FINDS AGENT WITH SAME EFFECT AS NERVE GAS

WASHINGTON, D.C.—Senator Frank E. Moss, Democrat of Utah, said today the Army told him that sheep tissue, forage and snow taken from the area where 6,400 sheep died contained an agent which produced a similar depressed cholinesterase condition that the nerve agent the Army sprayed from an airplane would produce.

The airplane test took place the day before the sheep began dying as part of the chemical and biological weapons testing conducted at Dugway Proving Ground in Utah.

The Army also said the agent they had found in the snow sample was neither a pesticide nor an insecticide.

"The Army will now compare the test agent to the agent found in the sheep tissue, forage and snow. It will take about a week to complete the tests, and if the agents are the same, that will establish whether or not the Army test at Dugway caused the deaths," Senator Moss said. The laboratory tests are being conducted at Ames, Iowa, and Atlanta, Ga.

Brig. Gen. William W. Stone of the Army, who heads the Army's investigation, also said that the Army has been feeding sheep hay with low levels of the nerve agent in it. Over a period of days they have developed the same symptoms as the sheep that died after the air test.

Senator Moss said he is still convinced the Army test caused the deaths, but is willing to wait for the laboratory comparison tests to be conducted before introducing a bill calling upon the Army to pay for the sheep.

"Certainly the preponderance of evidence indicates the test caused the deaths," Senator Moss said.

Senator Moss said he would expect the Army to tighten their safety precautions to make certain such a mishap does not occur again.

"The compensation to the sheep owners is, of course, secondary to making certain such a mishap does not happen again. The protection of humans and livestock in the future is the important factor."

Senator Moss said he was happy to see the Army was cooperating with the other governmental agencies, both State and Federal, in the investigation.

APRIL 2, 1968.

[News release from Senator Frank E. Moss]

TESTS SHOW ARMY NERVE AGENT TEST DEFINITELY CAUSED SHEEP DEATHS NEAR DUGWAY PROVING GROUND

WASHINGTON, D.C.—Senator Frank E. Moss, Democrat of Utah, today announced that comparative tests conducted by two Government agencies have shown an unknown agent taken from the site of the sheep deaths in Skull Valley, Utah, was definitely nerve agent which was sprayed from an airplane during a test at the Army's Dugway Proving Ground.

The comparative tests were conducted by the Department of Agriculture at Ames, Iowa, and by the Public Health Service at Atlanta, Ga.

Results of the tests were delivered to Senator Moss by Brig. Gen. William Stone. General Stone said his investigative work is completed and he has filed his report. The report will now go through normal channels and will be releasable in a week or 10 days.

Last week the technicians at Ames found an agent in sheep tissue and forage from Skull Valley which depressed the cholinesterase. At Atlanta, an agent which also depressed cholinesterase was found in snow taken from Skull Valley following the tests. Since then, the two laboratories have been working the comparative tests, using an agent identical to that which the Army had sprayed from an airplane on March 13, the day before the sheep began dying.

"This is proof positive that the Army spray test caused the deaths," Senator Moss said. "Up to now the evidence has been very substantial, but this makes it positive.

"It is now up to the Army to accept claims from those who lost their sheep, and I would recommend that they now file such claims. If legislation is necessary, I will introduce it following Easter recess.

"What's more important is that the Army gives assurances that such an occurrence will not happen in the future. Their safety precautions obviously need an entire overhauling.

"Dugway has been a welcome participant in the Utah economy for 26 years, and I look forward to that cooperation continuing. I have every confidence that they can correct the safety breach which resulted in this one situation, and that they can continue to operate safely in the future," Sen. Moss said.

APRIL 10, 1968.

Appendix 4.—Department of Defense, Office of Public Affairs, Washington, D.C., April 18, 1968, "Status Report on Investigation of Sheep Deaths in Utah"

For the Press:

Brig. Gen. William W. Stone, Jr., Office of Research and Laboratories, Army Materiel Command, has completed the initial phase of the Army's investigation into the cause of the death of the sheep in the Skull Valley area of Utah. His report is now undergoing technical review by scientists and staff officers in the Department of the Army.

This investigation was conducted at Dugway Proving Ground, and in Skull Valley and Rush Valley by technical teams from the proving ground, Edgewood Arsenal, U.S. Public Health Service, U.S. Department of Agriculture and Utah State Departments of Health and Agriculture. These teams operated independently but in a highly cooperative manner, exchanging all information obtained.

The Army investigations are continuing and its findings to date have not been conclusive as to the specific cause for the death of the sheep. The evidence pointing to Army involvement is as follows:

(*a*) Symptoms of an unknown sickness were reported as appearing on March 14, 1968, in the sheep at White Rock in Skull Valley, close to the eastern border of Dugway Proving Ground, and 27 miles east of the test site. By March 15, 1968, large numbers of sheep started dying at White Rock and in other herds of sheep further to the east in Skull Valley. The highest death rate was among the sheep at White Rock. The deaths in sheep occurred following a spray trial of a persistent chemical nerve agent from a high performance aircraft on March 13, 1968, at Dugway Proving Ground.

(*b*) Although there was a wind from the south-southwest at the time of the March 13, 1968, test, the wind shifted about 2 hours later and blew from the west. It can be postulated that any very small particles of agent remaining airborne could have been transported into the areas in Skull Valley and Rush Valley where sheep were later affected.

(*c*) There were scattered cumulus clouds in the general area at the time of the test and scattered rain showers developed during the early evening. One of these rain showers could have washed this airborne agent out of the air and deposited it on vegetation and the ground.

(*d*) Cholinesterase depression in the blood of affected Skull Valley sheep points toward exposure to an organophosphorus compound. Many common pesticides, the nerve agents, and some noxious plants can cause this depression.

Cholinesteras depression in the blood is the most sensitive indication of exposure to nerve agents or pesticides. This depression occurs at exposure levels well below those where there are visible or otherwise noticeable symptoms.

(*e*) Although symptoms of the affected sheep differed initially from those expected from past laboratory experience with other animals, continued feeding experiments with the agent have essentially reproduced the later symptoms found in the sick Skull Valley sheep.

(*f*) The total report indicates an extremely wide variety of possibilities as to what caused the sheep deaths; these have been explored and eliminated. There is no current evidence that the cause of death is to be found among poison plants, pesticides, or bacterial or viral infections.

(*g*) Since March 20, 1968, several hundred samples of water, soil, snow, vegetation, and wool from Skull and Rush Valleys have been analyzed looking for evidence that the agent has escaped from the proving ground; all these samples were negative. Recognizing that something had in fact killed the sheep and that it could have been the agent, a few very large samples of vegetation were collected by Dugway Proving Ground scientists from the White Rock area to obtain increased sensitivity. By April 10, 1968, this difficult analysis had proceeded in the proving ground laboratories and elsewhere to the point where it was con-

sidered possible that traces of a nerve agent or a similar organic compound were present in two extracts of samples collected in the White Rock area. Although there are still confirmatory tests to be completed in several laboratories on these and other samples, this is an indication that the agent could be present in an area where sheep died. Intensive collection of additional large samples in other areas where sheep died is now going forward. Confirmatory laboratory findings are also being sought from large samples sent to Edgewood Arsenal and the National Communicable Disease Center.

Since that date the National Communicable Disease Center, Atlanta, Ga., reports that their scientists have now isolated traces of an identical organophosphorus compound in snow, water, and grass, and in the blood, liver, and stomach contents of dead sheep in Skull Valley. It can be concluded that these compounds are related to the nerve agent samples provided by Dugway Proving Ground. Tests conducted to date at the Department of Agriculture Laboratories at Ames, Iowa, have not confirmed these findings.

Although the foregoing evidence points to the Army's involvement in the death of the sheep it is also clear that there are many questions still unanswered and which should be the subject of continuing investigation. For example:

(*a*) Why have sheep been affected seriously with no effect on humans whatsoever and only a slight cholinesterase depression in cattle and perhaps horses. The rodent population density before and after the test is unchanged. Apparently the sheep were affected by eating contaminated vegetation. However, to obtain the sheep deaths observed, from the small amount of agent that current data indicate could have gotten to Skull and Rush Valleys as a result of the March 13 test, the sheep by some as yet unknown mechanism must have become highly sensitized to the agent. The opinion that the deaths were caused by a combination of factors, of which the agent was only one, has been orally expressed by many of the investigators, Army and otherwise.

(*b*) As long as the possibility exists that the Army may have been involved, the existing safety procedures at the Dugway Proving Ground Laboratories need to be reviewed by an unbiased group. In this regard the Department of the Army has proposed the formation of a Federal interagency committee to conduct such a review. This proposal suggests the participation of representatives of the U.S. Department of Health, Education, and Welfare, Department of the Army, Fish and Wildlife Service, Department of the Interior, U.S. Department of Agriculture, Utah State Division of Health, Utah State Department of Agriculture, National Aeronautics and Space Administration and representatives from private agencies with special capabilities. This proposal is currently under consideration by the Department of Defense.

There is no evidence of any hazard to humans in the area.

Appendix 5.—"CHEMICAL WEAPONS—What They Are, What They Do," by Victor W. Sidel and Robert M. Goldwyn (From "Scientist and Citizen," Special Chemical and Biological Warfare Issue, August–September 1967)

In our brief review, we shall restrict the term "chemical weapons" to agents which produce their effects directly as a result of their chemical properties rather than as a result of blast, heat, or other physical effects of a chemical reaction.

Chemical weapons may be used against plants or animals, including man. Examples of herbicides, which have been used in Vietnam, as both defoliants (1) and agents for crop destruction (2), are given in table 1 but we will not elaborate on them since they are discussed in detail elsewhere in this issue.

Antipersonnel chemical weapons may be divided into six arbitrary categories; considerable overlap among these groups and individual agents exists, but in general they form a spectrum from the least lethal to the most lethal and are shown in table 1 in increasing order of lethality. The six groups are: irritants (tear and nausea gases); psychochemicals; vesicants (blistering agents); lung irritants; oxidizing enzyme inhibitors, and anticholinesterases ("nerve gases").

Irritants.—These agents, particularly the tear gases, have long been used to quell civil disturbances under the rule of law, but had not until recent years been widely employed in international combat. Effects of these agents include eye irritation, cough, shortness of breath, nausea and vomiting. Examples include DM (diphenylaminochloroarsine) an agent with a pepper-like odor that incapacitates for periods of half an hour to 2 hours; CN (chloroacetophenone), a form of "tear gas" that may also irritate the skin and incapacitates for about 3 minutes; and CS (O-chlorobenzalmalononitrile), a more recently developed lacrimatory and nausea-inducing agent that incapacitates for 5 to 10 minutes (3, 4, 5). Although these weapons are generally nonlethal, there is at least one reported case of death attributed directly to their use: an Australian soldier was asphyxiated while using these gases to clear tunnels despite the fact that he was wearing a gas mask (6).

Psychochemicals.—These agents, some of which are also known as hallucinogens, lead to mental derangements that are usually reversible. (7) The substance most frequently discussed is d-lysergic acid diethylamide (LSD–25). (8) This compound is odorless, tasteless and colorless, and effective in extremely small amounts. LSD may produce a wide range of psychopathologic reactions and psychoses, including an inability to concentrate, severe anxiety and manic states and complete catatonic withdrawal. Some preliminary research results suggest that LSD may cause chromosome damage, possibly resulting in thus far unknown effects on descendants of those exposed. (9) (One type of chromosome damage observed suggests the possibility of leukemia, also.) These agents can be dispensed covertly into the air or orally ingested. An additional hazard of psychochemicals, in contrast to other chemical weapons, is that the victim may be unaware of his altered behavior. An investigating congressional committee viewed a film that "demonstrated that troops exposed to one of these agents were not even conscious of their abnormal condition, a state so changed that they were unable to follow simple commands and perform normal tasks with acceptable accuracy." Only an outsider not exposed and coming upon them would recognize their behavior as eccentric. (10)

We have listed BZ among the psychochemicals, but it is not clear from the unclassified literature into which category it should be placed. Elinor Langer writing in "*Science*," states:

It (BZ) has both physical and mental effects, but its precise nature is not clear; unclassified information is notably less ample than for other chemical agents. The Army technical manual (TM 3-215) lists the following effects: Interference with ordinary activity; dry, flushed skin; tachycardia; urinary retention; constipation, slowing of physical and mental activity; headache; giddiness; disorientation; hallucinations; drowsiness, maniacal behavior (sometimes); and increase in body temperature. The weapons-employment manual warns that there are critical limitations to the use of BZ but cites the usefulness of incapacitants against intermingled enemy and friendly military units and against mixed populations of friendly, enemy, and civilian personnel. (11)

Vesicants.—Agents of the blistering type used in World War I included sulfur mustard ("mustard gas") which caused about 25 percent of the casualties in the American Expeditionary Force, and lewisite, an agent containing arsenic. A new distilled mustard and two kinds of nitrogen mustards are now available for military use.(12) Low concentrations of sulfur mustard will cause eye and skin blisters, which can be deep and may require weeks or months of healing. High concentrations will have more profound effects on the body such as alteration of heart rhythm and shock. The victim who survives the initial effects may later show damage to the bone marrow and ulceration of the gastrointestinal tract.(13) The vesicant agents in their gaseous phase are more insidious than the irritants, because their effects may not be noted for several hours; the victims may unknowingly remain in the atmosphere until severe damage is done. Furthermore, *liquid* mustard—the "gas" is a liquid at room temperature—penetrates leather, clothing, plastics and other materials. Since the liquid material may evaporate very slowly it can cause casualties several weeks later.

Lung irritants.—This group includes the World War I gases, chlorine and phosgene. Of these only phosgene is still considered a weapon for possible use in warfare, and it too has been rendered relatively obsolete by the newer lethal nerve gases. The military disadvantages of phosgene are its low toxicity, the high concentrations required, its telltale odor of new-mown hay and the delay in its pathologic effects (several hours to 24 hours). It has been reported that both mustard gas and phosgene gas have been used in the Yemen Civil War where republican forces are supported by Egypt and royalist forces by Saudi Arabia. (14, 15) The International Red Cross has investigated and made a report to the four governments concerned, but the report has not been made public.

Oxidizing enzyme inhibitors.—These agents, an example of which is hydrocyanic acid ("prussic acid") are very rapidly acting poisons and have been used for executions in "gas chambers."

Anticholinesterases.—Of the chemical weapons these are the newest and the most effective. They are colorless and odorless and enter the body as gases via the lungs or as liquids through the skin. These weapons were developed and stockpiled by the Germans in World War II but were never used. The German

names for the volatile agents of this type were Tabun, Sarin and Soman, and the corresponding American codes for these "G agents" are GA, GB and GD. Other, less volatile, substances of the same type are the V agents, particularly a liquid called VX. GB has been produced in the Rocky Mountain Arsenal in Denver. (16) Earthquakes in Denver have been attributed to the storage of its waste products underground at high pressure. (17) One of the nerve gases is produced at a plant in Newport, Indiana. (18) The size of its stockpiles is unknown, but the magnitude of the stockpiling operation may be surmised from the Washington Post disclosure that the Indiana facility, with three hundred civilian employees, has been operating for 24 hours a day for over 3 years. The final products of the assembly line in this plant are chemically filled rockets, land mines and artillery shells. The officer in charge of the plant states that "from Newport, the rockets and artillery shells are shipped in normal Army channels." Army Field Manual FM3–10 gives detailed instructions to field commanders for tactical use of these weapons. (19) One of these gases was reported used in Yemen, in addition to irritants such as mustard gas, and Israeli sources state that it was stockpiled by Egypt in the Sinai Peninsula. (15)

These newer gases possess almost all the qualities that make an excellent chemical-warfare agent. (20) Odorless and colorless, they give no warning; they act rapidly and effectively in low concentrations, being about thirty times as toxic as phosgene, and fourteen times as toxic as sulfur mustards. A few inhalations, at the air concentrations attainable under field conditions, can cause a blood concentration sufficient to kill in one or two minutes. (16)

For greater detail on specific weapons, table 2 is taken directly from "Tomorrow's Weapons, Chemical and Biological" by Brig. Gen. J. H. Rothschild, U.S. Army (retired), former commanding general of the U.S. Army Chemical Corps Research and Development Command, with the permission of the publisher. All of this information, and the information in table 1, is derived from the open literature.

From a military point of view, chemical agents possess certain specific advantages:

They are relatively cheap and easy to produce.

They cover a wide range of effects and persistency, so that a commander can tailor an attack to his tactical needs. For example, most gases persist for a short time. If a longer-lasting effect is desired, a liquid may be used which evaporates to produce the effective gas over a prolonged period.

Many different types of delivery systems—overt and covert—are possible. Examples include spray from a low-flying aircraft, delivery by bomb or missile, and introduction into water or air supply.

Many agents are colorless and odorless and therefore extremely difficult to detect. Effective protection and treatment are delayed and may be impossible.

TABLE 1.—CHEMICAL WARFARE AGENTS

Type of agent	Examples	Type of effects: Early	Type of effects: Late	Time of onset	Duration of action
HERBICIDES					
Some official definitions classify these chemicals as biological warfare agents.	2,4-Dichlorophenoxyacetic acid (2,4-D) [1 2 3] 2,4,5-Trichlorophenoxyacetic acid (2,4,5-T) [1 2 3] Cacodylic acid (dimethylarsinic acid) [2 3]	Destruction of soft-stemmed (2,4-D) and woody (2,4,5-T) plants [1] and rice and elephant grass (cacodylic acid) [2 3]	Short persistence in soil [2] Low toxicity to man and animals [2] (Cacodylic acid may be relatively more toxic.[3])	Days [2]	Weeks to months [2]
ANTIPERSONNEL (USUALLY NONLETHAL)					
Irritants (tear and nausea gases; sternutators and lacrimators)	Benzyl bromide [4] Bromacetone (BA) [5] Chloracetone [4] Chloracetophenone (CN) [4 5 6 7 8] O-Chlorobenzalmalonitrile (CS) [6 8] Diphenylaminochloroarsine (Adamsite; DM) [6 7 8] Diphenyl cyanoarsine [7] Ethyl bromoacetate [4]	Local irritation of mucosa leading to lacrimation, coughing, sneezing, nausea, vomiting [7 8 9]	Rare: Nerve damage [10] or asphyxia [11]	Seconds to minutes [9]	Minutes (CN, CS) to hours (DM) [8 9]
Psychochemicals	D-Lysergic acid diethylamide (LSD-25) [8 12 13] Mescaline [8] Psilocybin [8 13] BZ [8]	Distortion of perception [12 13 14]	Rare: Prolonged psychosis, or self-injury, while under influence of agent [13]	Minutes to hours	Hours to days [14 16]
Skin necrotizers	Phosgene oxime [7]	Pain, redness of skin	Necrotic skin; delayed healing not unusual [7]	Seconds to minutes [7]	Days to weeks [7]
ANTIPERSONNEL (MAY BE LETHAL)					
Vesicants (blistering agents)	Bi-(2-Chlorethyl)-sulfide (mustard; HO) [4 17 7] Chlorovinyldichloroarsine Lewisite; I) [4 7 17] Nitrogen mustards [7 17] Phenyldichloroarsine [7]	Erythema and blistering of skin, cornea, respiratory tract [7 18]	Infrequent: Aplasia of bone marrow; dissolution of lymphoid tissue; ulceration of the GI tract [7 19]	Skin and eyes: minutes to hours; respiratory tract: hrs. to days [18 20]	Days to weeks. May produce permanent systemic damage [7 19]
Lung irritants (choking gases)	Chlorine [4 5 7 21] Chlorpicrin (PS) [5 7] Diphosgene [4 5 21] Methyl sulfuryl chloride [4] Carbonyl chloride (Phosgene; CG) [4 5 21]	Damage to bronchiolar epithelium leads to pulmonary edema [21]	Frequent pneumonia; possible permanent lung damage [22]	Minutes to hours [22] (Phosgene has latent period; Chlorine and Chlorpicrin do not)[7]	If not lethal, days to weeks. May produce chronic lung disease (10% of survivors) [22]

ANTIPERSONNEL (USUALLY LETHAL)

Oxidizing enzyme inhibitors	Cyanogen bromide [4] Hydrogen arsenide (Arsine; SA) [17] Cyanogen chloride (CK) [4 5 17] Hydrogen cyanide (Hydrocyanic acid; Prussic acid; AC) [4 5 17]	Inhibition of oxidizing enzymes leads to tissue asphyxia [23]	Usually death [23]	Seconds to hours [23]	Generally lethal [23]
Anticholinesterases ("nerve agents")	Dimethylamidoethoxylphosphorylcyanide (German: Tabun; American: GA) [4 7 24] Isopropylmethylphosphoro fluoridate (German: Sarin; American: GB) [4 7 24] 1,2,2-Trimethylpropyl methylphosphorofluoridate (German: Soman; American: GD) [24] (VX) [24]	Prevention of breakdown of acetylcholine at nerve endings leads to muscular fasciculation, convulsions, respiratory paralysis, and death [7 24]	Usually death. If immediate effects survived, recovery may be complete [7 24]	Inhalation: seconds to minutes; skin absorption: minutes to hours [25]	Generally lethal [25] If anoxia does not cause brain damage, recovery in weeks to months [7]

[1] Raymond, J. "Weed Killers Aid War on Vietcong." New York Times, Mar. 28, 1965.
[2] Beecher, W. "U.S. Will Step Up Defoliation Missions in Vietnam." New York Times, Sept. 10, 1966.
[3] Galston, A. W. "Herbicides and the War in Vietnam." Scientist and Citizen, this issue.
[4] Stokes, J. D. "Chemical, Bacteriological, and Radiological Warfare." J. Kentucky Med. Assoc. 62:24–30, 1964.
[5] Prentiss, A. M. "Chemicals in War." McGraw-Hill Book Co., New York, 1937. Table IV facing p. 262.
[6] Raymond, J. "Gas as Weapons: Pro and Con." New York Times, Mar. 28, 1965.
[7] Sim, Van M. "Chemicals Used as Weapons in War." In Di Palma, J. (ed.). Drill's Pharmacology in Medicine. McGraw-Hill Book Co., New York 1958, pp. 971–982.
[8] Langer, Elinor. "Chemical and Biological Weapons (II).—The Weapons and the Policies." Science 155: 299–303, Jan. 20, 1967.
[9] Rothschild, J. H. "Tomorrow's Weapons—Chemical and Biological." McGraw-Hill Book Co., New York, 1964, pp. 43–44.
[10] "Tear Gas May Impair Nerves, Nectrotize Skeletal Muscles," Medical Tribune, Feb. 13, 1966, p. 1.
[11] "Gas and Smoke Hit Diggers." Brisbane (Australia) Courier Mail, Jan. 13, 1966, p. 1.
[12] U.S. Senate, Committee on Foreign Relations. "Chemical-Biological-Radiological (CBR) Warfare and its Disarmament Aspects." Government Printing Office, Washington, D.C., 1960, p. 12.
[13] Pollard, J. C., L. Uhr and E. Stern. "Drugs and Phantasy: The Effects of LSD, Psilocybin, and Sernyl on College Students." Little, Brown & Co., Boston, 1965.
[14] Rothschild, pp. 39–43.
[15] Ibid, p. 15.
[16] Pollard, p. 200.
[17] U.S Senate, Committee on Foreign Relations, p. 11.
[18] Rothschild, pp. 37–38.
[19] Goodman, L. S. and A. Gilman. "The Pharmacological Basis of Therapeutics: A Textbook of Pharmacology, Toxicology, and Therapeutics for Physicians and Medical Students" (second edition). Macmillan, New York, 1955, p. 1415.
[20] U.S. Department of Health, Education, and Welfare. "Effects of Chemical Warfare Agents." Government Printing Office, Washington, D.C., July 31, 1959, p. 5.
[21] U.S. Senate, Committee on Foreign Reations, p. 10.
[22] Goodman and Gilman, pp. 1096–1097.
[23] Ibid, pp. 931–934.
[24] Rothschild, pp. 32–36.
[25] Ibid, pp. 196–197.

Chemical weapons are pervasive and can reach hiding places inaccessible to other types of weapons; therefore they can incapacitate or injure personnel without destroying facilities.

Military disadvantages in the use of chemical weapons include their dependence on meteorological conditions such as temperature, wind, or smog, and whether or not they are released in open or closed spaces. If a non-lethal, incapacitating effect is desired, for example, this may be obtained by using tear gas out of doors. The same gas employed in holes, tunnels, or shelters may have a different effect; under these circumstances of poorly circulating air, a higher dose of the agent will be breathed in and death can result. This, as noted above, has actually happened in Vietnam—to an Australian soldier wearing a gas mask. (6)

From a civilian rather than a military point of view, the question before governments and their citizens is whether there are reasons for restraining the military use of chemical agents through unilateral statements of national policy or through international compacts. It has been argued that chemical weapons are more humane than others—especially when compared with such weapons as napalm, saturation bombing, or nuclear weapons. The authors have expressed their personal opinion elsewhere. (21) The relevant facts are:

The weapons now available and described above range from the relatively benign agents of rather limited military effectiveness to those that are permanently crippling or lethal and quite effective militarily. A ban on all chemical weapons would remove the whole range from the arsenal of the nation or nations concerned. To devise a definition that would forbid the use of nonlethal agents while permitting the use of lethal ones, is extremely difficult. For example, the incapacitating and presumably nonlethal gases, like all chemical and biological weapons, are notoriously uneven in their dispersal and therefore in the amount absorbed by each recipient; to insure that every person receives an incapacitating dose, some may have to receive an overdose. The young, the elderly and the infirm would be the particularly susceptible victims. Thus, to assure that it remains within the nonlethal category, even the most benign of the chemical weapons would require the delivery of a precisely measured dose to a standard victim, something impossible to achieve in battlefield conditions. Indeed, the widespread rather than specific targeting, exposing combatants and noncombatants alike, has been one of the objections of chemical warfare. Furthermore, nonlethal chemical agents can be used as an adjunct to increase the effectiveness of "conventional" weapons. For example, tear gas has been used in Vietnam prior to antipersonnel bombing, to drive people into the open. (23)

TABLE 2.—PROPERTIES OF REPRESENTATIVE CHEMICAL WEAPONS

[From "Tomorrow's Weapons" by J. H. Rothschild, Copyright (c) 1964 by J. H. Rothschild. McGraw-Hill Book Co. Used by permission.]

Name of agent, U.S. symbol	Physical state at 68° F.	Disseminated form	Odor	Median lethal dosage on inhalation [a] (mg.-min./m.³)	Median incapacitating dosage on inhalation (mg.-min./m.³)	Eye and skin [b] toxicity
Phosgene CG	Colorless gas	Gas	New-mown hay; green corn.	3,200	1,600	None.
Tabun GA	Colorless to brown liquid.	Aerosol, liquid or gas.	Faintly fruity; none when pure.	400 (resting men); 100 (active men).	300 (resting men)	Eyes: Very high; skin: 1½ grams liquid (30 drops).
Sarin GB	Colorless liquid	Gas or liquid	Almost none when pure.	70 (mild activity); 25 (active men).	35 (mild activity)	Eyes: Very high; skin: 15,000 [a] lethal for gas. 2 grams liquid (40 drops) through ordinary clothing; 8,000 [b] incapacitating for gas.
VX	Colorless liquid (persistent).	Aerosol or liquid	None			Eyes: Very high; skin: Very high.
Mustard HD	Colorless to pale yellow liquid.	Gas or liquid	Garlic; very little if pure.	1,500 (resting men; 400 (active men).		Eyes: 200 [b] incapacitating; skin: 2,000 [b] incapacitating for gas.
CS	White crystalline solid.	Aerosol	Pungent, peppery			Lethality low but incapacitating at 1–5 mg./m.³

Name of agent, U.S. symbol	Time of onset of symptoms	Physiological action	Protection required	Decontamination	Tactical use	First aid
Phosgene CG	Immediate to 24 hours	Damages the lungs	Mask	None in open; aeration in closed spaces.	Lethal agent, delayed or immediate action.	If shortness of breath occurs, rest and keep warm.
Tabun GA	Inhalation: Very rapid; skin: ½–1 hour.	Anticholinesterase agent (nerve gas).	Mask and protective clothing.	Bleach slurry; dilute alkaline solution; hot soapy water; DS2.	Lethal agent; inhalation or spray.	Atropine; artificial respiration.
Sarin GB	do	do	do	do	do	Do.
VX	do	do	do	do	do	Do.
Mustard HD	Delayed; 4–6 hours	Injures eyes and lungs. Blisters skin.	Mask and protective clothing; protective ointment.	Bleach DS2	Incapacitating agent, inhalation, skin effects from gas, spray.	Protective ointment on exposed skin (within 5 minutes); if liquid present, blot off first.
CS	Instantaneous	Extreme burning and tearing of eyes; difficult breathing; stinging of skin; Nausea.	Mask	None	Incapacitating agent on inhalation; normally a riot agent, but may be used as a war agent.	Face wind in fresh air; do not rub eyes.

[a] Concentration times exposure (milligrams per cubic meter times minutes) to cause death in 50 percent of subjects. The numbers are directly comparable to indicate lethality of the agents.

[b] Same as above but to cause incapacitation in 50 percent of subjects.

If there is no ban on chemical weapons, it appears unlikely that military commanders will limit themselves to the less effective ones; but will use those most effective militarily—and these are the more lethal.

The chemical weapons which have been officially sanctioned and officially disclosed by the United States for use in Vietnam are the irritants CS, CN, and DM (3.4). In addition, it has been alleged by a French reporter, that the incapacitant BZ has been used (23), but this has not been confirmed by official U.S. Sources. The use of tear gas by the Vietcong has been reported on at least two occasions (24, 25), although the Vietcong denied the first report (26).

There is an increasing concern over the development and stockpiling of chemical, as well as biological, weapons by the United States (12, 27) and by other countries. This policy has been repeatedly questioned in recent publications (22, 28, 29, 30) from tactical, medical and/or moral viewpoints.

ACKNOWLEDGMENTS

The authors are grateful to members of the Executive Committee of Physicians for Social Responsibility and of the Scientific Division of the Committee for Environmental Information for their helpful suggestions. We are especially indebted to Miss Robin Boucher for her careful editing of the manuscript and the references.

REFERENCES

1. Raymond, J. "Weed Killers Aid War on Vietcong." New York Times, March 28, 1965.
2. Beecher, W. "United States Will Step Up Defoliation Missions in Vietnam." New York Times, September 10, 1966.
3. Raymond, J. "Decision on Gas Made in Saigon." New York Times, March 24, 1965, page 1.
4 "Gas as Weapon: Pro and Con," New York Times, March 28, 1965.
5. Rothschild, J. H. "Tomorrow's Weapons, Chemical and Biological," New York, McGraw-Hill Book Co., 1964, pp. 43–44.
6. "Gas and Smoke Hit Diggers: one Dies, six Sick." Brisbane, Australia, Courier Mail, January 13, 1966, page 1.
7. Lieberman, E. J. "Psychochemicals as Weapons," Bull. Atomic Sci. 18: 11–14, 1962.
8. Rothschild, pages 39–43.
9. Irwin, Samuel and Jose Egozcue, "Chromosomal Abnormalities in Leukocytes from LSD–25 Users," Science, 157: 313, July 21, 1967.
10. U.S. House of Representatives, Committee on Science and Astronautics, "Research in CBR." Washington, D.C., Government Printing Office, 1959, page 10.
11. Langer, Elinor. "Chemical and Biological Weapons (II)—The Weapons and the Policies," Science, 155: 299–303, January 20, 1967.
12. U.S. Senate, Committee on Foreign Relations. "Chemical-Biological-Radiological (CBR) Warfare and its Disarmament Aspects" Washington, D.C., Government Printing Office, 1960, page 11.
13. Goodman, L. S. and Gilman, A. "The Pharmacological Basis of Therapeutics: A Textbook of Pharmacology, Toxicology, and Therapeutics for Physicians and Medical Students" (second edition), New York, Macmillan, 1955, page 1415.
14. Hamilton, Thomas J. in the New York Times, June 3, 1967.
15. Childs, Marquis, in the St. Louis Post-Dispatch, June 18, 1967.
16. Rothschild, pp. 32–36.
17. Janson, D. "Nerve Gas Waste Linked to Quakes," New York Times, March 26, 1966.
18. Polk, J. R. "U.S. Assembly Lines Turn Out Deadly Nerve Gas for Military," The Washington Post, April 22, 1964, p. 1.
19. U.S. Army. "Chemical and Biological Weapons Employment." Washington, D.C., Department of the Army, Field Manual FM3–10, February 20, 1962.
20. Sim, Van M. "Chemicals Used as Weapons in War," in Di Palma, J. (ed.) "Drill's Pharmacology in Medicine," New York, McGraw-Hill Book Company, 1958, pp. 971–982.
21. Sidel, V. W. and R. Goldwyn. "Chemical and Biological Weapons—a Primer," New England J. Med. 274:21–27, January 6, 1966.

22. Tear Gas Dropped Before B-52 Raid," New York Times, February 22, 1966.
23. Darcourt, P. "Le Temps des Massacres," L'Express, March 14–20, 1966, pp. 37–38.
24. "Tear Gas Is Used in Attack on G.I.'s," New York Times, November 11, 1966.
25. "Gas Grenades Used by Vietnamese Foe," New York Times, January 18, 1967, p. 1.
26. "Vietcong Denies Use of Tear Gas on G.I.'s," New York Times, November 16, 1966.
27. Langer, Elinor. "Chemical and Biological Weapons (I)—The Research Program," Science 155 : 174–179, January 13, 1967.
28. Krickus, R. J., "On the Morality of Chemical/Biological War," J. Conflict Resolution 9 :200–210, 1965.
29. Rosebury, T. "Medical Ethics and Biological Warfare," Perspective in Biology and Medicine 6 : 512–523, 1963.
30. Mayer, J. and V. W. Sidel. "Crop Destruction in Viet Nam," The Christian Century 83 : 829–832, June 29, 1966.

Appendix 6.—Reports by Dr. C. C. Gordon, Associate Professor of Botony, University of Montana, Missoula, Mont. (A—"East Helena Reports on Air Pollution Abatement"; B—"Cominco American Report.")

A—East Helena Reports on Air Pollution Abatement, December 16, 1968

This is the first report of studies carried out within a 4-mile radius of the American Smelting & Refining Co., located in East Helena, Mont. The study was initiated originally to determine the severity and extent of sulfur dioxide damage to the vegetation in the area. However, because of the presence of heavy metals which have been emitted by the smelting processes in this area, the study was expanded to include the amounts and effects on the ecosystem of these metals. An extensive review of the literature concerning some of these heavy metals was undertaken, and in the appendix of this report are verifax copies of the more pertinent articles.

The American Smelting & Refining Co. initiated smelting operations in East Helena in 1888, and subsequently the Anaconda Co. built a smelter adjacent to A.S. & R. in 1928. Therefore, the accumulation of heavy metals in the soil of the surrounding area has not occurred over the last decade but instead over the last 80 years. According to several ranchers that I talked to in the East Helena area, raising horses has not been feasible for several decades there because of the presence of lead and arsenic. The American Smelting & Refining Co. installed new equipment to increase production in 1967. In October 1968 when I talked to Mr. Stanley M. Lane (manager of the East Helena A.S. & R. smelter) in his office, he did not in any way imply that A.S. & R. had installed additional abatement equipment when production capacity was increased. Mr. Lane, after questioning the intent of my studies (I told him that I was concerned with sulfur dioxide damage and possible toxic levels of heavy metals in agricultural crops in the area), stated that he believed that the residents of East Helena should not raise garden vegetables.

This report presents the data which I have accumulated during the last 6 months. It is divided into three parts: (1) Methods and materials employed in the study, (2) results obtained, and (3) discussion of results and my opinions on the data accumulated thus far.

Methods and Materials

Plant studies.—On July 26 3-year-old seedlings of *Pinus ponderosa* and *Pinus sylvestris* (Scotch pine) were planted on four locations in the East Helena area. Five ponderosa and five Scotch pines were planted at each of the four locations at the following homes: (1) Kleffner's, located 1,800 yards southeast of the A.S. & R. stack, (2) Bessler's, 800 yards southeast of the stack, (3) Marche's, 1,800 yards southwest of the stack, and (4) Meihle's, 700 yards north of the stack (in the city of East Helena). Needles were collected and photographs taken of the seedlings on August 7, September 9, 18, and 27, and October 11 and 25. Needles from these seedlings were cut into two millimeter sections, killed in FAA (formaldehyde, acetic acid, and alcohol), and processed through the tertiary butyl alcohol series into paraffin. The material was sectioned on a rotary microtome at thicknesses of 7 and 10 micra, stained with Feulgen's solution and fast green, and studied with the use of a phase microscope.

Some damaged indigenous and horticular herbs, shrubs, and trees growing within a 3-mile radius of the plant were collected for study. The most readily apparent damage in the area was to the *Carragana* hedges in town and to the wheat growing directly southwest of the stack. Photographs were taken of this damage. Both photographs and leaf collections were taken of *Populus* and *Salix* species which grow in the Prickly Pear Creek drainage south of the plant.

Garden vegetables as listed were collected from the following ranches and residences:

1. Ken Diehl; 2 miles east of the A.S. & R. stack (beets, carrots, corn, and wheat).
2. Robert Armagast; 2 miles north of the stack (beets, carrots, and potatoes).
3. Jack Meihle; in town of East Helena, 700 yards from stack (beets, carrots, corn, and green beans).
4. Paul Kleffner; 1,800 yards south of the stack (beets, carrots, cucumber, and corn).
5. Paul Bessler; 800 yards south of the stack (corn, beets, carrots, cucumber, chard, and cabbage).
6. Melvin Johnson; 2 miles west of stack (corn and summer squash).
7. Howard Stratton; 1½ miles northwest of stack (beets, corn, cucumber, lettuce and squash).
8. Hatlelid; 1¾ miles northwest of stack (beets, corn, cucumber, lettuce and squash).
9. University of Montana faculty garden; located on Evans and Helena Avenue in Missoula, Mont. (beets, carrots, and corn); controls.
10. Elmer Flynn; Missoula Valley (wheat); control.

These samples were sent to the Wisconsin Alumni Research Foundation laboratory where they were analyzed for cadmium and lead content.

Animal studies.—Rather than trapping rodents in the East Helena area, an exploratory sampling of domesticated animals' tissues was undertaken. Increased abortion of litters in rabbits owned by Paul Bessler was suspected to be due to cadmium or lead. Consequently two adult female rabbits (13 months old) and one young female (2 months old) were selected from Bessler's animals. These rabbits had been continuously caged near his home and fed only commercial rabbit feed (no indigenous or garden-grown vegetation). One of these 13-month-old rabbits was fed vegetables from Bessler's garden for 30 days and then killed. This rabbit was designated R–1. The other older rabbit (designated R–2) and the young female (designated R–3) were killed immediately. A control rabbit (12 months old) designated R–4, raised in Missoula and fed commercial rabbit feed and alfalfa was selected. Portions of the livers and muscle tissue of all these animals were sent to Wisconsin for cadmium and lead analyses.

Just adjacent to Mr. Bessler's home is a small farm on the Prickly Pear Creek drainage owned by Mr. Sumner. Because the American Smelting & Refining Co. had called in a veterinarian to test the lead content in the blood of three of the more than 40 pigs being raised by the Sumners, two animals were collected from this farm for lead and cadmium analyses. One animal was a domestic 1-year-old rabbit (designated R–5) which had been running wild around the barnyard for its entire life, and the other animal was a 2-month-old pig. Muscle and liver tissue of the rabbit and heart, liver, kidneys and muscle tissue of the pig were sent to Wisconsin for analyses. No control pig tissues were analyzed for comparison.

RESULTS

Sulfur dioxide damage.—Twelve days after the ponderosa and Scotch pine seedlings were planted in East Helena, necrosis and banding of current year needles were apparent. The only exception was the conifer seedlings at Kleffner's (which were at an equal distance from the A.S. & R. stack as those at Marche's showing damage). By September 9, 1968, severe needle necrosis had occurred on the conifers at Kleffner's. Histological studies of needle tissues from all four conifer sites revealed that the disease syndromes manifested by both scotch and ponderosa pine were similar to those obtained when same-aged seedlings were exposed to toxic concentrations of SO_2 in laboratory tests.

It is obvious from checking conifers growing in East Helena yards that damage prior to 1968 was not as severe as that which occurred during the growing season of 1968. This conclusion is based on the understanding that current year needles are much more susceptible than older needles and, depending upon the species, needles are retained on the branches from 4 to 8 years (4 years for *Pinus* species and 8 years for *Picea* species). Of the more than 20 conifer trees checked in East Helena, little evidence of damage occurring to needles prior to 1968 was observed. However, since spruce (*Picea*) is much less susceptible to SO_2 damage than are the *Pinus* species, subphytotoxic concentrations (for spruce) could have occurred for many years without being readily apparent.

No conifer foliage was sent to the Wisconsin Alumni Research Foundation laboratory for total sulfur analysis. However, if this study is to continue during

the summer of 1969, analysis for total sulfur in new foliage should be undertaken.

Accumulation of lead and cadmium in vegetable gardens and wheat.—Because of the nature of the processes used by the smelters in East Helena, a check was made of vegetables and wheat grown in the area for lead and cadmium. The vegetable collections were made in October 1968 and, consequently, the samples consisted mainly of root vegetables rather than leafy vegetables which had been frozen by that time. As much as the gardens permitted, collections were standardized. Beets, carrots, and corn appear in most of the collections. Winter squash and potatoes were included when available because they were judged to represent a greater potential source of metals than onions, tomatoes, lettuce, and other products which were likely to be consumed by the gardner for only a few weeks. Similar amounts of the vegetables were used in making up the samples sent for analysis. All vegetables in the sample were homogenized before testing so that values given for lead and cadmium represent the average for the vegetables included rather than for any single vegetable. Wheat samples were tested separately. Results of these tests are shown in table I.

Since plants grown in the area appeared to have accumulated lead and cadmium, several domesticated animals were collected and their tissues analyzed for these metals also. The results of these analyses are given in table II.

TABLE I.—VEGETABLES AND WHEAT ANALYZED FOR LEAD AND CADMIUM

Resident	Location	Vegetables	Parts per million on a dry weight basis	
			Lead	Cadmium
(a) Ken Diehl	2 miles east of East Helena	Beets, carrots, corn	2.2	0.44
(b) Robert Armagast	1 mile north of East Helena	Beets, carrots, potatoes	1.1	.57
(c) Jack Meihle	800 yards from stack, lives in East Helena.	Beets, carrots, corn, green beens.	22.5	2.04
(d) Paul Kleffner	1 mile south of A.S. & R. stack	Beets, carrots, corn, green beans.	6.0	.70
(e) Paul Bessler	800 yards south of A.S. & R. stack	Beets, carrots, corn, cucumbers, chard, cabbage.	48.0	5.31
(f) Melvin Johnson	3 miles west of A.S. & R. stack	Corn, summer squash	<1.7	<.42
(g) Howard Stratton	2½ miles northwest of A.S. & R. stack	Beets, corn, cucumbers, lettuce, squash.	2.9	<.71
(h) University of Montana faculty garden.	Missoula, Mont., 125 miles from East Helena.	Beets, carrots, corn	<.7	.17
(i) Ken Diehl	2 miles east of East Helena	Wheat	.8	.34
(j) Hatlelid	3 miles west of A.S. & R. stack, next to M. Johnson's.	do	1.9	.39
(k) Paul Kleffner	1 mile south of A.S. & R. stack	do	1.7	.90
(l) Senator Elmer Flynn	Missoula Valley, 125 miles from East Helena.	do	<.5	.20

TABLE II

Resident	Animal	Feed	Tissues	Parts per million on a dry-weight basis	
				Lead	Cadmium
Bessler	Mature rabbit, R–1	Vegetables from Bessler's garden for 30 days.	Muscle	<1.1	0.3
			Liver	33.5	10.2
Do	Mature rabbit, R–2	Commercial feed only	Muscle	<1.5	<0.35
			Liver	<1.4	<1.40
Do	2-month-old rabbit, R–3	do	Muscle	<1.7	<0.35
			Liver	2.16	<0.35
Rewey (Missoula)	Mature rabbit, R–4	Commercial feed and alfalfa grown on premises.	Muscle	<1.53	<0.35
			Liver	<1.28	<0.35
Sumner	Mature rabbit (running wild), R–5.	Native vegetation	Muscle	1.49	0.3
			Liver	28.4	6.7
Do	Suckling pig (2 months)		Heart	<1.3	<0.3
			Kidney	12.6	14.5
			Liver	11.5	2.0
			Muscle	4.2	0.5

Note: Commercial feed used by Bessler contained 2.50 p.p.m. lead and 0.60 p.p.m. cadmium on a dry-weight basis.

DISCUSSION AND CONCLUSIONS

Sulfur dioxide.—While the obvious high concentration of SO_2 is causing necrosis in indigenous vegetation as far as 4 miles south of the plant, the more important danger from this gas is the high concentration of sulfuric acid mist which undoubtedly forms close to the A.S. & R. smelter when the humidity is high. The wheat growing just adjacent to the plant probably was not damaged directly by SO_2 but rather by sulfuric acid mist. If this study is continued, monitoring for sulfuric acid mist within a 1-mile radius of the smelter would be advantageous.

Plots of two or three species of pines should be planted this spring (1969) and the study area extended to a 4-mile radius from the smelter. Controls should be planted between 6 to 10 miles from the A.S. & R. stack. Both histological studies and analysis of total sulfur accumulation in vegetation should be considered.

Lead and cadmium studies.—The most important botanical question at the present time, in my opinion, is where is the lead and cadmium coming from which accumulates in the garden vegetables. From the data thus far gathered by the State board of health and my studies, there are several enigmas. For instance, at the east station (1½ miles from the A.S. & R. stack) 180 p.p.m. on August 4, 1967, and 156 p.p.m. on December 8, 1967, of lead in grass was reported. At that time the soil at this station had 2,320 p.p.m. of lead. Yet Ken Diehl's garden vegetables (2 miles east of the stock) contained 2.2 p.p.m. of lead and Paul Bessler's garden vegetables (800 yards south of the stack) contained 48 p.p.m. of lead. According to the State board of health records, the grass growing south of the stack contained only 72 p.p.m. lead on August 4, 1967, and the soil contained 430 p.p.m. lead. Soil and grass lead contents seem to be positively correlated while garden vegetables show the reverse of that expected. This leads me to believe that atmospheric assimilation may be a price source of lead and cadmium accumulation in garden vegetables rather than soil-root translocation. A chart has been prepared to show how the concentrations of lead and cadmium in garden vegetables differ from soil concentrations of these elements. It should also be noted that during my visits to East Helena during the summer of 1968 the prevailing wind was usually out of the northwest and north. Also, SO_2 damage to vegetation was much more severe in a southerly direction from the stack than in any other. Thus it is probable that the plants in Bessler's garden were accumulating lead and cadmium from the atmosphere through the leaf surface. A single test would confirm or refute this hypothesis rather easily. This summer soil could be taken from each of the four East Helena stations where the concentration of lead and cadmium in the soil is known. This soil would be placed in 10- by 10-foot plots at a farmhouse 10 miles to the north of the stack. Wtih a similar sized plot at each station, the same vegetables (preferably vegetables, but perhaps grass species) would be planted in all eight plots. Within 60 days, we should be able to determine how much is being accumulated by root translocation and how much by leaf assimilation.

From the human aspect, the most important question is how serious are the lead and cadmium concentrations in the vegetables, domestic animals, and ambient air. While studies of mammals in the East Helena area were not within the boundaries originally set by my verbal agreement with the State board of health, the known serious effects of lead and cadmium poisoning caused me to increase the scope of this study. The concentrations of lead and cadmium in the liver and kidney tissues of Sumner's pig and in the liver of their domestic rabbit which subsisted on native vegetation on their farm indicate that these animals should not be eaten. The difference in concentration of lead and cadmium between the two mature rabbits of Bessler's, one of which was fed Bessler's garden vegetables for 30 days prior to being sacrificed, makes clear that an extensive health problem is very probable in East Helena. A continuing study on lead and cadmium concentration on domesticated farm animals should be carried out in East Helena. Since lead poisoning is so deleterious to young children, all East Helena schoolchildren should be checked for chronic lead and cadmium poisoning. Growing of vegetable gardens should be discontinued within a 1-mile radius until further studies on mode of plant accumulation of these metals is determined.

Concurrent with the tests outlined above, it is imperative that the air pollution abatement equipment of both the A.S. & R. and the Anaconda smelter in East Helena be monitored for efficiency.

B.—Cominco American Report, December 6, 1968

INTRODUCTION

On numerous occasions during the last 6 years I have fished and hunted in the Flint Creek Mountain Range and dug for antique bottles around the old abandoned miners' cabins and towns. Since 1965 I have collected hundreds of vegetation samples around Garrison and in the Gold Creek area. Consequently, I am familiar with the vegetation of the area.

Most of the plant species which are characteristic of the northwest Palouse Prairie occur in the drainages of Gird, Douglas, and Gaskill Creeks. These drainages of Mount Princeton and Douglas Mountain run for the most part north-northwest. The lower elevations of these three drainages are semiarid with 10 to 14 inches of rainfall annually. Ecologically, this lower area represents the dry phase of the Palouse Prairie and is composed mainly of the following grass species: Blue bunch wheat grass (*Agropyron spicatum*), Idaho fescue (*Festuca idahoensis*), June grass (*Koeleria cristata*), Sandbergs bluegrass (*Poa secunda*) and some rough fescue (*Festuca scabrella*). Further up these same drainages where tree density increases and the annual rainfall exceeds 14 inches (usually 15 to 17 inches) Pine reed grass (*Calamagrostis rubescens*) occurs with the usual Palouse Prairie grasses and conifers. The more common larger herbs in this area are balsam root, lupine, hairy golden aster, two species of pussy toes (*Antennaria spp.*), hawk weed (*Hieracium sp.*) and geraniums. The three main species of conifers in order of frequency are Douglas-fir, Rocky Mountain juniper and ponderosa pine. Except on the very driest rocky ridges (where Rocky Mountain juniper and ponderosa pine are about equally dense). Douglas-fir is by far the dominant conifer in the three drainages. The most common shrubs in the higher area are snowberry (*Symphoriocarpus*), ninebark (*Physocarpus*), service berry (*Amelanchier*), and various species of *Rosa*, while in the lower drier habitat, fringe sage (*Artemisia frigida*) and rabbit brush (*Chrysothamnus spp.*) are common.

The first time I collected vegetation for histological analysis around the Cominco American phosphate plant on Douglas Creek was in the summer of 1966. I also collected in this area in the early summer of 1967. These collections were made primarily to ascertain whether Mr. Bryce Rhoades' assertion was true that part of the flouride problem occurring in the Gold Creek area was attributable to the Douglas Creek operation of Cominco American. At the U.S. Public Health Service hearing in Deer Lodge in August 1967, I stated that histological studies on conifer needles collected around the Cominco American plant showed no damage to conifer needles due to hydrogen fluoride-containing dust on them. I still maintain this to be true. If trees are killed by this coating of dust, it will be due entirely to a plugging of the stomatal openings and reduction of photosynthesis, not to assimilation of HF. In the Douglas Creek area there are very few dead trees and it did not seem necessary to include any dead trees in the current study. This study was undertaken to answer the following questions:

1. How much fluoride is present in the particulate matter on the grass forage in the area?
2. How much fluoride is present in the particulate matter on the bailed hay of Mr. Boomer?
3. How much fluoride is present in the particulate matter on conifer needles?
4. How much flouride will be present in the forage of the fields owned and leased by Mr. Boomer next spring?
5. What effect will the fluoride-containing dust have on the total ecosystem of the Gird Creek, Douglas Creek, and Gaskill Creek drainages?

Adequacy of sampling is often an issue in a courtroom. In the evaluation of data some of the points to be considered are: (1) Are the collections representative of the area? (2) Were there enough samples taken to prove statistically that a true appraisal of the situation was obtained? (3) How much of the fluoride in the particulate matter on the forage is assimilated by the cattle? and (4) How accurate are the chemical analyses? These questions will be discussed later in this report where they are relevant.

MATERIALS AND METHODS

Plant samples.—Collections: Douglas-fir branches with needles were collected from the following areas: (1) directly above the Cominco American plant (200 yards up the slope); (2) one-half mile past the cattle guard (three-fourths mile from the plant) on the road that runs south up toward the mine; (3) the ridge that separates the Gird Creek and Douglas Creek drainages; and (4) the ridge east of Boomer's ranchhouse on which strip mining by Cominco American occurred.

Twenty-five grass samples were collected from fields either owned or leased by Mr. Boomer. Three of these samples were sent to the Wisconsin Alumni Research Foundation for flouride analysis (A–2, C, and D). One large hay sample was taken from a stack of baled hay located 300 yards from Boomer's home. The hay was cut from the field next to the house and parallel to Boomer's driveway. This large sample of hay was a composite of grasses taken from 10 different bales of hay, some of which were outside bales (exposed to weather) and some inner bales (as far as I could reach into the stack). This composite hay sample was sent for fluoride analysis (E). Five samples of grass were collected right around the Cominco American plant. One of these samples was halved, and one-half was sent for analysis on October 29 (designated B) and the other half was washed with agitation for 4 hours in running tap water and sent for analysis on November 4 (designated B–1C).

Histological studies: Samples of needles from each collection location were prepared for histological studies using the paraffin embedding technique. Two millimeter sections were cut from 1966, 1967, and 1968 needles. These pieces were put into a solution of formaldehyde, ethyl alcohol, and acetic acid (FAA), put under vacuum for 24 hours, then processed through a tertiary butyl alcohol series into paraffin. Needle pieces embedded in paraffin were cut into thin sections (10–15 micra) on a microtome and placed on microscope slides. The needle sections were stained with Feulgen's solution and fast green so that the various needle tissues could be more readily studied.

Histological studies were also conducted on 10 of the grass samples. Technical procedures used for the grasses were the same as those employed for the conifer needles.

Chemical analyses: Two of the Douglas-fir samples used in histological studies were sent to the Wisconsin Alumni Research Foundation for analysis of fluoride content. One was collected 200 yards directly above the slope (sample F) and the other from the land leased by Mr. Boomer three-fourths mile from the plant and one-half mile past the cattle guard (sample A–1). These two samples were not washed so fluoride content listed is that within the dust which adhered to the needles after being handled during collecting. Six of the 31 grass samples collected and two conifer needle samples were sent to the Wisconsin Alumni Research Foundation for fluoride analysis.

In summary the samples sent for analysis were—

A–1. Douglas-fir foliage collected one-half mile up the road from the cattle guard on Boomer's leased land and three-fourths mile from the plant.

A–2. Grass collected from beneath the trees of collection A–1.

B. Grass from slope 200 yards directly up the slope from the Cominco plant.

B–1C. Same collection as B but washed with agitation for 4 hours.

C. Grass on the eastern slope above Boomer's home, toward the ridge that separates Douglas Creek and Gird Creek drainages.

D. Ungrazed fenced land next to plowed field about 200 yards from Boomer's house; this is in the bottom of the draw in which Boomer's house is located.

E. Hay sample from stack of baled hay 300 yards from Boomer's house; hay was cut from field in the draw that sample D was taken from.

F. Douglas-fir foliage from same area as grass sample B was collected.

Rodent samples.—Three meadow mice (*Microtus pennsylvanicus*) were trapped in the field where grass sample C was collected. The femur bones were removed from each of the mice and sent for fluoride analysis.

RESULTS

Histological studies.—Microscopic studies revealed that even after the needle sections had been processed through numerous chemical solutions in preparation

for sectioning, a large amount of phosphate dust clung tenaciously to the outer surface of both conifer and grass leaves. In general, foliage samples collected at increasing distances from the Cominco American plant had decreasing amounts of dust coating their surfaces. There are a few exceptions to this and they are easily explained by the barrier effect of the ridges in the area and the prevailing wind patterns. For instance, at equal distances there is a heavier concentration of dust on foliage north of the plant than there is south of the plant. There are significant differences in dust accumulation on grass leaves from the ridge between Boomer's house and the main Douglas Creek drainage (approximately 700 yards south of Boomer's house) and from around Boomer's ranch home. Current histological studies substantiate earlier studies of 1966 and 1967 that the fluoride in the phosphate dust is not assimilated by the plant tissue and that there are no disease symptoms in any of the foliage samples which could be attributed to fluoride or hydrogen fluoride. As mentioned in the introduction, damage could occur from the decrease in photosynthesis caused by the presence of the dust coating on the foliage. Because of the time required, a study to substantiate this expected effect was not considered feasible at this time.

Chemical analyses.—Fluoride analyses of grass and tree foilage indicate that there is a positive correlation between dust accumulation and fluoride content. Chemical analyses also indicate that with increasing distances from the plant fluoride content in vegetation decreases. The following are data from the Wisconsin Alumni Research Foundation report on fluoride content in foliage samples (locations as reported above):

Sample	*Concentration of fluoride in p.p.m.*
A–1: 1968 and 1967 Douglas-fir needles	1,600
A–2: Rough fescue grass and blue bunch wheat grass	510
B: Blue bunch wheat grass and rough fescue grass	1,290
B–1C: Same as B, but washed with agitation for 4 hours	465
C: Timothy, alfalfa, and Palouse prairie grasses	505
D: Johnson quack grass and rough fescue grass	74
E: Alfalfa and timothy hay	80
F: 1968 and 1967 needles of Douglas fir	2,600

Rodent trapping analyses.—The three specimens of *Microtus pennsylvanicus* (meadow mouse) were collected on the open east slope in the vicinity where grass sample C was collected. The femur bones (back leg long bones) of these mice contained fluoride in parts per million as follows: (1) 11,900, (2) 14,600, (3) 14,300. A meadow mouse's diet consists of grasses, sedges, roots, and bulbs. Specimens of *Microtus pennsylvanicus* collected in the Garrison area during the summer of 1967 had femur fluoride concentrations of 424 p.p.m. and 423 p.p.m. at Von Bergen's (1,000 yards from Rocky Mountain phosphate plant) and 449 p.p.m. near the Golden Spike gas station (almost 4 miles from the plant). Of the seven house mice (*Mus musculus*) captured on Mollengerg's land (600 yards from the plant) during June 1967, the average fluoride content of the femur bones was 9,812 p.p.m. The highest value was 12,700 p.p.m. and the lowest, 7,170 p.p.m. The five house mice captured in Missoula as controls at that time averaged 480 p.p.m. of fluoride in their femur bones; no control mice were analyzed in the current study. Although the solubility of the fluoride-containing dust on the foliage is best determined by a chemist, it is evident from this study on mice that a large amount of fluoride in this dust is being assimilated and accumulated by the animals that feed upon the vegetation around the Cominco American plant.

DISCUSSION

In the introduction of this report, I questioned the validity of a small sample versus a large sample, since the data accumulated from a small sample may not be representative of the area. I believe there is no need to obtain a larger number of samples from the Cominco American plant area at this time, for the following reasons:

First, even after continuous washing and agitation, the fluoride-containing dust adheres tenaciously to the surfaces of the vegetation. Therefore, even next spring, after snow melt, at least one-third of the fluoride will remain on the vegetation.

Second, new growth of the grasses will not be produced in sufficient quantity until mid-June to dilute the fluoride in foliage remaining from the 1968 growing season to an acceptable level.

Third, fluoride content of grass samples taken from most of Boomer's grazing land until next June will exceed the limit of 35 p.p.m. set by the State board of health as permissible for forage.

So that the fluoride content of forage in the Douglas Creek area could be compared to that in another fluoride-polluted area, concurrent studies were conducted in the vicinity of the Anaconda Co. aluminum smelter in Columbia Falls. In the past 6 months, severe hydrogen fluoride damage has occurred to conifers within a 4-mile radius of this plant. Reports of fluorotic cattle have been confirmed by the State veterinarian. Grass and conifer samples collected on both nongrazing and grazing lands in the area and analyzed for fluoride content confirm that many of these samples exceed the State maximum of 35 p.p.m. fluoride for forage. For instance, grass collected on the south side of Columbia Falls' city limits (3 air miles from the aluminum plant) contained 70 p.p.m. of fluoride (on a dry weight basis). Conifer needles collected 2 miles from the aluminum smelter at the Pleasant View Apartments contained 163 p.p.m. of fluoride. Alfalfa collected at Mr. C. Sedivy's ranch 2½ miles northeast of the plant (at the base of Teakettle Mountain) contained 195 p.p.m. of fluoride. Fluorosis of cattle was confirmed by the State veterinarian at Mr. Sedivy's ranch. The above are the highest fluoride concentrations obtained in the Columbia Falls area, while hay at 21 p.p.m. from Doan's ranch (1½ miles due south of the aluminum plant) represented the lowest concentration. This again illustrates the effect of prevailing wind patterns and the valley effect caused by high ridges or mountains.

Since the fluoride in the Columbia Falls area is assimilated as a gas (hydrogen fluoride), the fluoride is contained within the tissues of the foliage. This is not the case in the Douglas Creek area. Here the fluorides are bound in the calcium fluorophosphate dust on the surface of the foliage. This dust, while only slightly soluble in water, is more soluble in acid solution such as is present in the digestive tract of mammals. Consequently, although fluoride contained within the plant tissues is more readily absorbed by mammals than that bound in the surface phosphate dust (as is the case in the Douglas Creek area), mammals eating this dust-coated foliage assimilate enough fluoride to adversely affect their health.

CONCLUSION

It is my opinion that the fluoride-containing dust which has accumulated on the vegetation in the drainages of Gird, Douglas, and Gaskill Creeks has caused serious damage to the area's ecosystem and will continue to do so for at least 8 more months. The domesticated animals will continue to ingest and assimimlate fluoride above legal amounts until next July when the new growth predominates over the 1968 growth of forage grasses. In 1969 large concentrations of the fluoride-containing dust can be expected to be washed into the creeks of the area during spring snowmelt and runoff. As a consequence, these water supplies need to be regularly checked this coming spring to avoid the potential problem of fluorosis in the domesticated animals from this source.

The paramount consequence of this fluoride contamination is its effects on the native flora and fauna. For several more years the organisms of the area will be seriously damaged by the fluorides and phosphates within the dust. If this case goes to court. Dr. George Woodwell (one of the world's most renowned ecologists who carries out research at Brookhaven Laboratories, Mass.) will come at my request to testify that this dust has caused serious and irreparable damage to the ecosystem of this area. However, there is no way that I know of at this time to put a price on the damage to the ecosystem of that area.

As for the damage claims by Mr. Boomer and the other affected ranchers, the actual cost in damage to their livestock and hay and the cost of clean hay needed to supplement the fluoride-contaminated cattle rations this winter are legitimate damage claims. Attempts by the ranchers to magnify unrealistically their damages should be discouraged. Officials of Cominco American have indicated to me that they will willingly pay for damages which have been honestly appraised. Cominco American's excellent land restoration policy convinces me that this company is concerned with the damage its operations cause to the ecosystem.

If the ranchers wish, I will testify on the contents of this report in a court of law.

Appendix 7.—"Investigation of Sheep Deaths—Skull Valley, Utah," Department of Health, Education, and Welfare, Health Services and Mental Health Administration, DP, National Communicable Disease Center—Atlanta, Ga., April 29, 1968

EPIDEMIOLOGICAL INVESTIGATIONS

Through telephone conversation with Dr. Jordon Rasmussen, veterinarian-in-charge, USDA, ANHD, Salt Lake City, on March 21, he verified reports that approximately 5,000 sheep out of approximately 5,600 had died from an unknown cause in Skull Valley, Utah, near Dugway Proving Ground. Dead sheep had been examined by veterinarians from the USDA, the State of Utah, and practitioners, and the cause of death had not been determined. Dr. Rasmussen invited participation of NCDC personnel in the investigation of the cause of the deaths. Through conversations with the director of the Division of Health, Utah Department of Health and Welfare, Dr. G. D. Carlyle Thompson, arrangements were made for a team with broad capabilities in medicine, veterinary medicine, virology, and epidemiology to go to Utah. At the request of Dr. Thompson, Dr. James W. Glosser reported to the office of Dr. Thompson at 8 a.m. on March 23. The others followed the afternoon of the same day.

Additional veterinarians were requested from NCDC and five joined the team on March 26. (app. I). The team was housed at Dugway Proving Ground which supplied transportation and their other needs. Cooperation between all groups engaged in the investigation was excellent (app. II). The focal point of the investigation became Brig. Gen. William W. Stone, U.S. Army Material Command, Washington, D.C. (app. III).

It was learned that on March 13, an operational test and evaluation of an aircraft spray system was made at Dugway Proving Ground using a persistent nerve agent containing organicphosphorus. The spray mission was flown by a high performance aircraft. Extensive preparations were made for the test which included marking the course of flight, two dry runs, and the use of monitoring devices to determine the actual test flight and dispersal of the test agent. The test agent had been used many times for more than 10 years at Dugway Proving Ground.

Low scattered clouds with a high thin overcast was observed at the time of the spray trial. There was a weak front in the area. The wind up to 2,300 feet above ground was generally from the southwest, 5 to 25 miles per hour with gusts up to 35 miles per hour. The ground was dry on all test grids at test time. The valleys and lower mountains were also dry; however, there was a light snow cover on the higher elevations. Rain showers and virga were first reported in the area about 6 hours after the test and continued during the night. Snow showers were reported 10 a.m. March 14.

On March 14 a band of about 2,800 ewes (band No. 1) grazing in the mountains approximately 20 to 25 miles northeast of the test site began showing signs of an illness described by the herder as "crazy in the head." Many of the sheep died during the night and most of the others were showing characteristic signs of the illness the next day. Also on March 14, another band of approximately 3,000 ewes (band No. 2) on range about 30 to 35 miles northeast of the test site showed signs of illness identical to those in the first flock. Many of these died during the night and the remainder developed the illness during the next few days.

On March 17 signs of illness identical to those in the first two bands were noted in three bands (bands 3, 4, 5) some 35 to 40 miles east of the test site. Mortality was high in one band.

On March 20 a few sheep in a band (band No. 6) of about 1,625 ewes located 45 miles east-northeast and over two mountain ranges from the test site, were noted to be developing signs of illness identical to those seen in the first five bands.

It was obvious to all that the signs of illness were the same in all sheep and that the illness was less severe in those farthest from the test site. None of the veterinarians or sheepmen recognized these signs as being those of any illness known to them. The signs of illness were ataxia, frequent attempts to urinate, stilted gait, falling down, arched neck and mandible at right angles to the sternum, torticollis in later stages and neurasthenia.

All affected sheep were in a fairly well-defined area northeast and east of the test site. This area can be described as generally cone-shaped about 50 miles long and 20 miles wide at the widest point. Cattle of all ages, nursing lambs, horses, wildlife, dogs, and people in this area showed no signs of illness. The cholinesterase levels of the cattle and horses were below normal. Sheep on range about 5 miles north and south of this area did not show any signs of illness.

Although there were no reports of unusual human illness in Skull Valley, three National Communicable Disease Center physicians surveyed the area and no illnesses or complaints were found which could be attributed to the test at Dugway or could be associated with sheep. Two episodes of school absenteeism were attributed to mumps and measles. Cholinesterase levels in the 43 persons tested of the 110 inhabitants of the affected area were within normal ranges.

Army personnel began extensive testing of the test agent in sheep and their response to treatment with atropine and 2–PAM upon development of signs of illness in sheep dosed with the test agent resulted in marked alleviation of these signs. Some animals relapsed later and developed characteristic signs of the illness in the range sheep in the affected area. Sick sheep from the range were treated with atropine and 2–PAM 9 days after illness appeared in the flock and they failed to respond. The NCDC veterinarians participated in these tests and also were used to evaluate reported new cases of illness in animals in the area.

The epidemiologic data gathered by the NCDC team indicated that the cause of the illness in sheep was a toxic agent other than poisonous plants or insects. However, extensive laboratory investigations by nine different groups (app. II) were performed to determine whether heavy metals or microbiological etiological agents were the cause of illness. There have been no reports to date indicating that any biological agent or heavy metals were involved. Results of tests performed by NCDC laboratories follow.

LABORATORY INVESTIGATIONS

Summary of chemical results

1. Water and forage from Skull Valley as well as blood and liver from ill sheep showed an agent which proved to be identical in chemical composition to a sample of test agent supplied by Dugway.

2. There was an initial shift in instrument response time, showing conditioning of instruments to the chemical and changes in the chemical on exposure to air. This later cleared up.

3. Rumen contents from ill sheep showed the same response on instruments as the authentic test agent furnished in water by Dugway, that is, hydrolysis products of test agent.

4. Infrared chromatograms of test agent, hay, and water extracts showed similar scans indicating identity of agents under study. An unusual peak not directly attributed to test agent has now been explained as due to acetone used in working up solutions.

5. Mass spectrometry of test agent, hay and water isolates prove beyond doubt that these responses are in fact identical and can only be attributed to the same chemical.

CHEMISTRY

The first samples in connection with the present sheep death incident were received in the pesticides program toxicology laboratory on March 25, 1968. Over the next 2 weeks, other samples trickled in to swell the total received to about 92. On Thursday, April 4, Dr. Brauner from Dugway Proving Ground and Dr. Sass from Edgewood Arsenal visited the laboratory to bring samples of supposed authentic material as well as infrared scans of their material. On Friday, April 5, the preliminary release was sent from NCDC reporting on first findings of significance. On April 12, the second release was sent from NCDC stating the

identity of the authentic material with isolates from samples from Skull Valley in Utah. On Tuesday, April 15 Dr. Rothenberg, scientific director of Dugway, accompanied by Dr. Houle and Mr. Bell visited the laboratory with further samples of the test agent as well as laboratory-prepared derivatives and supposedly related compounds. Rather than report on each individual sample this report will describe the type of analyses made and results obtained with interpretation where needed. See the attached table for list of samples (appendix IV).

CHOLINESTERASE IN BLOOD

Samples 375 and 376 blood from sick sheep in the problem area were centrifuged and the plasma run for cholinesterase activity by the pH Stat method and compared to samples 377–381 from Lawrenceville, Ga., used as controls. The former samples were shown to have a 50-percent inhibition in cholinesterase activity when compared with the controls.

Samples 383 to 425 from humans working in the problem area were also examined and were all found to be in the normal range with no evidence of depression.

Samples 506–517 from horses in Skull Valley were so hemolyzed that they were not usable for cholinesterase tests.

CHLORINATED HYDROCARBONS

The first two blood samples (375 and 376) were examined for chlorinated hydrocarbons by first extraction with hexane and then chromatography using electron capture detection with 4′ x ¼″ glass columns packed with 3 percent QF–1 on AW, DMCS, 70/80 mesh Chromosorb "G" in the gas chromatograph.

The DDT family of pesticides was detected at levels considered within the normal range for humans not occupationally exposed to pesticides.

Any possible intoxication with chlorinated hydrocarbons would have resulted in levels of an order of magnitude greater than that observed. This ruled out chlorinated hydrocarbons in connection with the incident.

ORGANOPHOSPHORUS DETERMINATIONS

The snow water sample 541 was divided into two fractions and extracted three times with 5 ml. portions of diethyl ether in separatory funnels. One fraction was made slightly acid and extracted. The other fraction was held neutral and extracted.

When the extracts were injected into the gas chromatograph equipped with a 6′ x ¼″ glass column packed with 3 percent SE 30 on AW, DMCS, 60/80 mesh Chromosorb "G," using flame photometer detector set up for phosphorus mode, two peaks were observed in the chromatograms at 2.6 and 8 minutes respectively.

When the blood was extracted with ether the peak was observed at 2.6 minutes. The kidney and liver extracts (ether) showed a trailing asymmetrical peak at 1 to 2.5 minutes. No peaks were observed in control sheep blood from the Lawrenceville, Ga., facility. When a sulfur filter was used instead of the phosphorus, a 2.6 minute peak was observed in the blood.

No peaks were observed from extracts of brain tissue.

Rumen contents (540a and 540b) showed peaks at 4.8 and 5.3 minutes respectively.

Grass sample (546) showed three peaks 2.6, 8, and 40 minutes respectively.

Control sample of test agent furnished by Dr. Brauner showed a peak at 5 minutes.

Control sample of test agent in water furnished by Dr. Brauner showed, after extraction with ether, a peak initially at 5 and then 4.3 minutes which kept shifting to shorter retention time.

Some of the test agent sample was used on a sodium chloride plate for infrared and was left behind when Dr. Brauner departed for Dugway. This was extracted with acetone from the sodium chloride and after removal of acetone dissolved in hexane, then injected into the gas chromatograph. The peak had now shifted to 2.6 minutes. Subsequent injection gave the same retention time, also the same retention time was observed when a sulfur filter was used.

The samples of water, forage, and blood all showed a peak at 2.6 minutes which was identical in shape and retention time to the 2.6 minute peak obtained

from the test agent extracted from the sodium chloride. The retention times of hydrolysis products of the test agent as furnished by Dr. Brauner as compared to the hydrolysis products as found in two rumen samples are almost the same.

The bis-simulant furnished by Dr. Brauner when chromatographed gave peaks at 1.9 and 11.2 minutes respectively. A word on the bis-simulant may be needed here. This compound was reported by the Army to have been used to simulate the test agent in trial runs because its physical properties so nearly matched that of the test agent. Many applications were reported to have been made of the bis-simulant over a considerable period of time. It was important to differentiate between the bis-simulant and the test agent. In the chemical studies this was done. The 2.6 minute peak was not related to the bis-simulant.

On April 16, Dr. Rothenberg and aides brought another sample of test agent in hexane as well as some laboratory-prepared derivatives reported to be related to the test agent as well as unrelated item GB. The test agent chromatographed at 3 minutes, differently than that originally found in the first sample of test agent from Dr. Brauner. This can be readily explained by the conditioning of the column in the interim period. The prepared derivatives failed to chromatograph. The GB showed no related pattern.

When the instrument was set up in the sulfur mode, that is, it would analyze for sulfur, a peak at 2.6 minutes was observed in the hay sample. This showed that the extracted chemical gave a response for both sulfur and phosphorus from hay, water, and the test agent.

INFRARED ANALYSIS

The original test agent supplied by Dr. Brauner was so dilute (100 p.p.m.) that it failed to give a usable infrared scan when applied to a sodium chloride plate. Five days after Dr. Brauner left, it was decided to try again, but this time using multiple internal reflectance technique. The sodium chloride plate was extracted with acetone, the acetone removed and replaced with hexane. A part of the hexane solution was used in the gas chromatograph equipped with a flame photometric detector containing a phosphorus filter. The phosphorus filter was subsequently exchanged for a sulfur filter. The rest was applied to a thallium bromide plate for multiple internal reflectance on an infrared spectrophotometer.

The multiple pass system produced a response that gave a usable scan. The water extract was also submitted to multiple internal reflectance and showed an identical scan to that observed with the extracted authentic test agent (from Brauner).

The infrared scan of the bis-simulant showed no relation at all to the peak isolated at 2.6 minutes from the blood samples or water or forage.

The observed shifts in absorption bands in the snow (water) as compared to the test agent (Dr. Rothenberg) after addition of acetone are identical. This indicates complexation of the solvent molecule (acetone) with that of a thin film of both the compound as isolated from snow and the test agent itself.

MASS SPECTROSCOPY

The LKB mass spectrometer proved to be an invaluable tool in this investigation. The water extract was injected into the gas chromatograph inlet of the instrument and examined. The water extract was also injected by direct probe into the source and examined.

The test agent extracted from the sodium chloride was also examined in the same manner. In this procedure, the clusters of peaks observed reflected a difference of 14 mass units with several other major ion fragments. The high mass fragments indicated dimerization of the molecule. Both the test agent and the water extract showed identity in great detail, not only in presence of mass response, but also ion intensity.

The hay was later examined and showed the same pattern. A 9′ x 3 mm. glass column packed with 3 percent SE 30 on AW, DMCS, 60/80 mesh Chromosorb "G" was used in the gas chromatograph.

COLOR

The extract of the snow water sample was found to have a red coloration. The laboratory staff were informed by Dr. Brauner and Dr. Huffaker that a red dye, Dupont Oil Red, was used in all test applications at Dugway so that the application could be photographed against the blue sky.

QUANTITATION

Since the laboratory staff had no authentic material in sufficient amount in the initial part of the investigation, quantitation was at first impossible. Later, when there was a chance to compare the response from the hay (sample 546) with that of the test agent supplied by Dr. Rothenberg, the rough quantitation was made that the hay contained 0.105 p.p.m. test agent. This is subject to two possible errors.

First, there was no way of knowing what percentage of the unknown material was extracted so the 0.105 is minimal. The other error reflects the difference in retention time. The pure sample gave a retention time of 3 minutes, while the hay artifact had the same retention time as the aged test agent—2.6 minutes. If the retention time changed, the response to flame photometric detection could also change to some unknown extent. From the very slight difference observed in retention time, it would not be expected that the quantitation response would differ materially. Other samples, sheep blood with an inhibited cholinesterase, and snow (water) contained an organophosphate with the same retention time (2.6 minutes) as the aged test agent.

Using the same methods of calculation and subject to the same errors, the water showed 0.2 micrograms per ml.

It is interesting to note that a sheep consuming this forage at the rate of 3 to 6 lbs. per day would consume 146 to 286 micrograms of test agent per day.

The forage from Dr. Kent R. Van Kampen (Veterinary Toxicologist, USDA Poisonous Plants Laboratory, Logan, Utah) that had been fed to sheep and produced symptoms (samples 557 and 558) showed 0.135 and 0.126 p.p.m. respectively. This forage gave identical response on gas chromatography to previous forage samples. If the sheep consume 3 to 6 lbs. of range forage per day, the animals would consume 167 to 368 micrograms of test agent per day.

MICROBIOLOGICAL STUDIES ON SAMPLES FROM SKULL VALLEY

All materials received by the laboratory program of the National Communicable Disease Center including a great variety of tissue suspensions, blood, cerebral spinal fluid, and rumen contents of several affected sheep (Nos. 203, 224, 428, plus some unlabeled), as well as the brain of an experimentally inoculated suckling sheep, were all negative in Duck embryo, Vero, and BHK–21 cell cultures (the first lot received was put into all three cell cultures; the last lot was put into Vero and BHK–21 only).

The organ suspensions of field-affected sheep, treated with penicillin and streptomycin, generally produced no symptoms in suckling mice over a 12- to 17-day period of observation. Rumen contents, however, brought mice down in 1 to 6 days with gross appearance compatible with bacterial contamination. The cerebrum of a suckling sheep which had died as a result of intracerebral inoculation of rumen contents produced deaths in suckling mice, but is negative on passage in presence of antibiotics.

There have been no viral isolations.

A variety of tissues from sheep including contents of rumen, reticulum, and abomasum were examined for bacterial flora and bacterial toxins. The cultures were attempted for plague, tularemia, anthrax, and anaerobes. Presently, there is no evidence of the presence of bacterial toxins or bacterial pathogens.

Histopathologic study of the brain of a lamb which died following inoculation of rumen contents, suggested superative meningitis and the presence of a gram negative rod. This was in no way connected with the Skull Valley incident.

The other participating agencies have taken samples for laboratory analysis, but at this writing, a final report on their work has not been received.

Although final reports have not been received by us, we have been advised in telephone conversation with Dr. B. P. McNamara at Dugway and Dr. Kent R. Van Kampen of USDA, Logan, Utah, that feeding and other studies with well sheep have now produced signs and symptoms of "Skull Valley Disease" that duplicate those observed on the range. These studies were reported to involve timed injections of the test agent, studies with antidotes, and feeding experiments with forage from Skull Valley.

DAVID J. SENCER, M.D.,
Assistant Surgeon General,
Director, National Communicable Disease Center.

APRIL 29, 1968.

Appendix I

NCDC Personnel Participating in the Investigation of Sheep Deaths, Skull Valley, Utah

Dr. James W. Glosser (veterinarian), NCDC activities, El Paso, Tex., Epidemiologist.
Dr. R. H. Huffaker (veterinarian), Assistant Chief, Veterinary Public Health Section, epidemiology program.
Dr. Robert D. Courter (veterinarian), Assistant Chief, Community Studies Section, pesticides program.
Dr. Robert Arko (veterinarian), Veterinary Public Health Section, epidemiology program.
Dr. Dan Hudson (veterinarian), Veterinary Public Health Section, epidemiology program.
Dr. Dennis Stubblefield (veterinarian), Veterinary Public Health Section, epidemiology program.
Dr. Paul Marques (veterinarian), Veterinary Public Health Section, epidemiology program.
Dr. Alan Poland (physician), Toxiocology Section, pesticides program.
Dr. Ronald E. Iverson (physician), Community Studies Section, pesticides program.
Dr. John Crowell (physician), Epidemiology program, assigned to Utah State Health Department.
Dr. Louis C. LaMotte (epidemiologist), Chief, Community Studies Section, pesticides program.

Appendix II

Agencies Participating in Sheep Death Investigation, Skull Valley, Utah

1. Dugway Proving Ground, U.S. Army.
2. Edgewood Arsenal, U.S. Army.
3. Utah State Department of Health.
4. Utah State Department of Agriculture.
5. National Communicable Disease Center, PHS, DHEW—Atlanta.
6. National Animal Disease Laboratory, USDA, Ames, Iowa.
7. Poisonous Plant Laboratory, USDA, Logan, Utah.
8. Department of Ecology and Epizoology, University of Utah.
9. Department of Animal Science, University of California, Davis.

Appendix III

Attendees at Coordination Conference, Dugway Proving Ground, April 1, 1968

Brig. Gen. W. W. Stone, U.S. Army Materiel Command, Washington, D.C.
Dr. G. D. Carlyle Thompson, director, division of health, Utah Department of Health and Welfare.
Dr. B. P. McNamara, Edgewood Arsenal, Md.
Capt. Gary D. Givens, preventive medical officer, DPG, Dugway, Utah.
Capt. Stephen R. Holmes, post veterinarian, DPG, Dugway, Utah.
Lt. George R. Harper, ecology and epidemiology, DPG.
Dr. Kenneth B. Brauner, chemical division, DPG, Dugway, Utah.
Dr. L. L. Solomon, biological division, DPG, Dugway, Utah.
Mr. Clair R. Olsen, test operations, DPG, Dugway, Utah.
Dr. Grant S. Winn, Utah State Division of Health.
Dr. Robert W. Sherwood, Utah State Division of Health.
Dr. John R. Crowell, Utah State Division of Health.
Dr. Jordon E. Rasmussen, veterinarian-in-charge, ANH, ARS, USDA.
Dr. Kent R. Van Kampen, veterinarian pathologist, ADP, ARS, USDA.
Dr. Marr O. Fawcett, veterinarian for hatch land and livestock.
Mr. E. J. Owens, Edgewood Arsenal, Md.
Maj. John F. Ferrell, Edgewood Arsenal, Md.
Capt. John A. Everts, Veterinary Corps, Edgewood Arsenal, Md.
Dr. James W. Glosser, veterinarian-epidemiologist, NCDC, Altanta, Ga.

Dr. Robert D. Courter, veterinarian, NCDC, PHS, Atlanta, Ga.
Dr. Robert H. Huffaker, veterinarian, NCDC, PHS, Atlanta, Ga.
Dr. D. A. Osguthorpe, veterinarian, Utah State Department of Agriculture.
Mr. H. Kent Francis, Utah State Department of Agriculture.
Col. James H. Watts, commanding officer, DPG, Dugway, Utah.
Dr. Mortimer A. Rothenberg, Scientific Director, DPG, Dugway, Utah.
Maj. R. J. Dunagan, USAF/TAWC, Eglin AFB, Fla.
Mr. J. Fred Owings, Plans Office, DPG, Dugway, Utah.
Capt. F. E. Cooper, Judge Advocate Office, DPG.
Mr. A. W. Watson, Jr., Ray, Quinney & Nebeker (attorney) Salt Lake City.
Lt. Col. J. E. Macklin, Headquarters, U.S. Army Materiel Command, Washington, D.C.
Mr. W. H. Palm, public information officer, Headquarters, U.S. Army Material Command, Washington, D.C.

APPENDIX IV

SAMPLES

In the course of this investigation, the following samples were received at the Toxicology Laboratory, NCDC, DHEW, Atlanta, Ga., for analysis and evaluation:

Date received	Laboratory number	Samples	Description
March 25	537	Sheep brain	Skull Valley sheep, animal lethargic, near death.
	538	Sheep liver	Do.
	539	Sheep kidney	Do.
	375	Sheep RBC	Do.
	376	do	Do.
March 26	377–381	Sheep RBC and serum	Control sheep from Lawrenceville, Ga.
March 28	383–425	Human blood	42 civilians living and working in Skull Valley (not working at Dugway).
Do	506–517	Horse RBC	Horses from Match and Redden Ranches.
March 29	540a	Rumen fluid	Taken at autopsy Skull Valley sheep.
	540b	do	Do.
Do	541	Snow (water)	From Skull Valley.
Do	382	Control rumen	Lawrenceville, Ga., sheep.
Do	542–544	Water	2 running water and 1 pond water.
Do	545	Wool	Wool from dead sheep.
	546	Forage	Forage from valley.
April 5	547–556	Contents of cecum, rumen, small intestine.	From ill sheep, collected by Dr. Huffaker in Skull Valley.
April 12	557–558	Forage	From Dr. Van Kampen, Logan, Utah. Samples taken at Skull Valley. This forage had been fed to sheep and produced symptoms.
April 5 [1]		Test agent	100 p.p.m. in hexane.
Do		do	In water (actually hydrolysis products).
Do		Simulant	Bis-2-ethylhexylphosphite.
April 15 [2]		Test agent	2 percent in hexane.
Do		do	Dealkylated derivative of above.
Do			Pyrophosphate derived from portions of molecule.
Do			GB in hexane, another CW agent.
Do			QLO, derivative of test agent.

[1] Supplied by Dr. Brauner, Dugway.
[2] Supplied by Dr. Rothenberg, Dugway.

APPENDIX V

The following information on the test agent was supplied from Dugway Proving Ground—March 25—Dr. McNamara. Lecture on VX experiments in sheep. Assume 40 kilograms per sheep.

IV: 10 microgram/kilogram IV (about 400 micrograms)—death in 3 minutes—5 microgram/kilogram IV (about 200 micrograms)—death in 1½ hour.

Percutaneous (feet plus face) application:

Dose:	*Deaths*
20 micrograms/kilograms	1/3
60 micrograms/kilograms	2/3
180 micrograms/kilograms	3/3

LD_{50}—30 *ug/kg*=1,200 *ug*

Percutaneous—to wool only—no effect, no symptoms at 400 migrograms/kilograms=16,000 micrograms.

Chronic oral feeding—at the end of 96 hours.

Dose	Deaths	Cumulative dose (ug)
50 ug tid (150 ug/day)	0/5	550
100 ug tid (300 ug/day)	2/5	1,100
300 ug tid (900 ug/day)	4/5	3,300

Terms:

IV	Intravenous.
ug	Microgram, 10^{-6} gm.
kg	Kilogram.
LD_{50}	Lethal dose to kill 50 percent.
tid	Three times a day.

Appendix 8.—Memorandum to Hon. Henry S. Reuss from Freeman H. Quimby, Specialist, Life Sciences, Legislative Reference Service, Library of Congress, Washington, D.C., on the subject of "The Hydrolysis of the Organophosphates as Related to the Toxicity of the Degradation Products of VX"—June 16, 1969.

The following memorandum is submitted in response to your request of May 28, 1969, concerning the nature of the products of organophosphate hydrolysis as a possible clue to the toxicity of residues of VX in the Dugway testing area:

Although the nerve gas VX is in a large group of chemical substances classified as organophospshorus poisons, we do not believe that the specific nature of its degradation products can be extrapolated from the known reactions or reaction mechanisms of the organophosphates in general. This is particularly true when considering the fate of VX and its hydrolysis products which may be introduced either deliberately or accidentally into the environment (soil, air, water, plants, animals). Radioactive isotope decay rates are dependent only upon the intrinsic property of the particular atom. The term half life is used to denote the time when one-half of any original number of atoms will have decayed. Decomposition rates of chemical compounds depend upon a great variety of conditions including temperature, presence of other compounds, concentration, ultraviolet light, physical state, and acidity of the medium. Decomposition may be partial or complete and the rate may vary during the period of reaction. Therefore, the rate of hydrolysis of VX and the persistence and toxicity of the products must be determined by direct experiment and observation. This fact is implicit in the "Report of the Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground" concerning the "persistence of toxic residues of *the* compound"; "the toxicological properties of *the* original molecules as well as those of *its* degradation products"; "degradation of chemical agents does not aways mean they have dissipated"; and "fundamental data required on the behavior and fate of *each* chemical in plants, soil, water, animals, and air." The report also points out that "in some instances the resulting metabolites (in animals and plants) may be even more toxic than the original molecules."

The conclusion of the recently released report of the NAS–NRC Committee on Persistent Pesticides may also apply to VX (although persistent refers to the chlorinated hydrocarbon type rather than organophosphorus pesticides: "Knowledge is incomplete concerning the fate and degradation of persistent pesticides in the environment, their behavior in the environment, the toxicity of the degradation products, and the interaction of these products with other chemicals."[1]

Since military chemicals are released into the open environment and since VX in particular is of low volatility, is persistent, and absorbed by plants, that section of the aforementioned *ad hoc* report dealing with "Fate of Agent in Environment" is reproduced below as being directly relevant to the question of the hydrolysis of nerve gases and the toxicity of their breakdown products:

"D. Fate of Agent in Environment:[2]

"1. The numbers and kinds of plants, animals, soils and the chemical, physical, and biological properties of the water and atmosphere at the Dugway Proving Ground test site and an offpost border area within a radius of several tens of miles adjacent to the test site must be known and understood. A thorough knowledge of the micro and macro ecology and climatology of the area must be developed. Such information is a prerequisite to an understanding of the behavior and fate of chemical agents in the test site at Dugway Proving Ground and in the offpost adjacent areas and is an integral part of the safety requirements for current and future types of testing at Dugway. The characterization criteria are as follows:

"(*a*) *Absorption or uptake.*—The absorption or uptake of chemicals by plants and animals is critically important. Chemicals may enter plants through their roots or leaves. They enter animals by ingestion, inhalation, or absorption through the skin. Chemicals that are absorbed by plants may be absorbed from

[1] Quoted from Food Chemical News, June 9, 1969, p. 5.
[2] Report of "The Interagency Ad Hoc Advisory Committee for Review of Testing Safety at Dugway Proving Ground," November 1968, pp. 17–19.

the soil, water, or air. Most chemicals are absorbed by the roots of plants and translocated to the above ground parts where they accumulate in the stems, leaves, and fruits. Many are also absorbed by the leaves of plants and are readily translocated to the roots. Species of plants vary widely in their efficiency to absorb chemicals from soil, water, or air through their leaves and roots. In many instances the tolerance of plants to chemicals is based on the differential absorption and translocation of chemicals from the soil, water, and air. The absorption and translocation of chemicals in food, feed, and forage plants is an important method by which chemical toxicants are removed from the environment and incorporated through the food chain into the bodies of humans, domestic animals, fish, wildlife, and other living organisms. Knowledge of the uptake and movement of chemical agents then becomes an integral part of the safety requirements in testing operations.

"(*b*) *Adsorption.*—Most chemicals are adsorbed by plants, soils, water, animals, and airborne particulates. The tenacity with which they are bound varies greatly among plants, animal tissues, soil types, and other surfaces. Adsorption by soils also varies greatly with their chemical, physical and biological properties. Adsorption in water depends largely upon the chemical physical and biological properties of the water and is greatly influenced by the amount of sediment and organic matter it contains. The adsorption of chemicals in air depends upon the airborne particulates and their chemical, physical, and biological properties. The activity of most chemical agents varies with soil composition. In soil systems adsorbed chemicals are gradually desorbed as leaching or chemical and biological degradation occurs and absorption by plants reduces the concentration in the soil solution. However the adsorption-desorption relations of chemical molecules in soils and the importance of these phenomena in the movement of chemicals in soils should be determined for the soil types and environmental area surrounding Dugway Proving Ground.

"(*c*) *Translocation or movement.*—Numerous factors influence the translocation of chemicals in plants. Once a chemical has been absorbed into the plant it may be immobilized in the treated tissue by adsorption to, or conjugation with, cell constituents. When some chemicals are absorbed the molecule is often metabolized prior to translocation. Food, feed, and forage plants are a primary sink for chemicals released into the environment. They are a major means through which exogenous chemicals in the environment enter human and animal bodies. Therefore, the safe testing and use of chemicals in the environment demand a knowledge of their absorption, movement, translocation, mechanism of action, metabolism, and toxicity to plants and toxicity to humans and animals that consume plants containing such chemicals.

"(*d*) *Metabolism and metabolites.*—The ability of animals and plants to convert nontoxic chemicals to toxic metabolites and to detoxify highly toxic chemicals has been well established in studies on the mechanism of action and metabolism of herbicides, insecticides, fungicides, nematocides, and other chemicals. It has also been demonstrated that similar conversions of chemicals can occur in soil, water, and air. It is therefore important to safe testing and the safe use of chemicals to understand the conversions chemicals undergo in plants, animals, soils, water, and air. In some cases, the metabolite might be less toxic than the original molecule and in some instances the resulting metabolites may be even more toxic than the original molecules. It is therefore imperative to determine the toxicological properties of the original molecule as well as those of its degradation products, intermediates, and metabolites.

"(*e*) *Volatility.*—All chemicals evaporate to some extent from the surface of plants, soils, water, animals, and airborne particulates. The degree and rate of their volatility is a major factor in the control of their distribution and movement. For this reason, the rate of evaporation should be determined from plants, soil, water, animals, and airborne particulates at a temperature 10° lower than the lowest temperature and 10° higher than the highest temperature recorded at Dugway Proving Ground. The effects of such factors as temperature, pH, soil type, vegetative cover, wind velocity, and other factors known to influence volatility of chemicals should be determined. It is especially important to understand the impact of particle size on volatility in relationship to deposition of chemical agents on targets.

"(*f*) *Photochemical changes.*—Studies have established the fact that chemicals are subject to photochemical changes in plants, soils, water, and air. The effect of photochemical changes on chemical agents should be determined by exposure of such agents to various light spectrums at a range of temperatures and other conditions that effect photochemical changes in chemicals.

"(*g*) *Chemical reactions.*—Some of the chemical reactions that chemicals undergo in plants, soils, water, animals, and air have already been discussed. Many chemicals are known to undergo hyrolysis, oxidation, and the formation of complexes in plants, soils, water, and air. The chemical reactions that organic chemicals will undergo in plants, soils, water, animals, and air are numerous. These chemical reactions need to be understood for maximum safety in testing and use.

"(*h*) *Persistence.*—An understanding of the persistence of chemical agents in plants, soil, water, animals, and air is essential in developing appropriate safety monitoring techniques. The persistence of chemical agents in the various soil types and the vegetative associations in the off-post areas surrounding Dugway Proving Ground, as well as the persistence of chemical agents in water, in animals, and in the atmosphere must be known.

"(*i*) *Degradation.*—An understanding of the degradation of chemicals in plants, soils, water, animals, and the atmosphere is essential to safe testing techniques. Degradation may occur through microbial action, volatility, chemical reactions, photodecomposition, and other processes. The process of degradation in plants, soil, water, animals, and air should be understood and the rate of degradation determined.

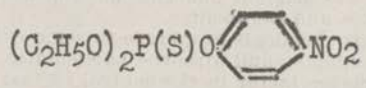
"(*j*) *Dissipation or excretion.*—Degradation of chemical agents does not always mean they have dissipated. The processes and rate of dissipation from plants, soils, water, and air should be known, as well as the rate of excretion from animals.

"(*k*) *Disposal and decontamination.*—Methods of disposal and decontamination should be available or developed for on-post and off-post use.

"2. A number of criteria for characterizing the behavior and fate of chemical agents in plants, soils, water, animals, and air have been discussed. Obviously, the necessity for, and thoroughness of, the fundamental data required on the behavior and fate of each chemical in plants, soil, water, animals, and air can vary depending on an assessment of the risk of the chemical agent reaching off-post locations inhabited by man, domestic animals, and wildlife. The greater the risk of the agent reaching off-post locations, the greater the need and the degree of understanding of the behavior and fate of the agent in the environment. It is, therefore, obvious that the thoroughness of understanding of the behavior and fate of the agents in the environment will have a significant impact on the development, implementation, and management of safety programs associated with testing at Dugway Proving Ground."

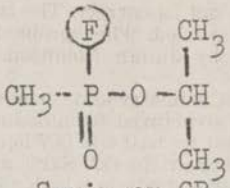
We have been asked to consider the possibility of deducing from a common organophosphorus pesticide (parathion), the hydrolysis products of VX and what their toxicity might be. While it is true that parathion certainly is in more common use than VX, it is possible that this situation could be quite the other way around. That is, that Army chemists and biologists may know more about the degradation of VX than civilian scientists know about parathion. The Dugway incident would, of course, tend to raise doubts about this knowledge; or at least doubts about the appropriate application of it.

At any rate, parathion does not appear to us to be a "type species" of the organophosphates, at least not any more so than any of the others. Unlike the nerve gases it does not, for instance, contain a fluoride (F) or cyanogen (CN) group. Parathion has the following structure:

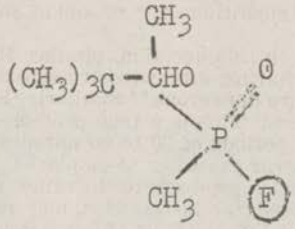


This compound under certain conditions hydrolyzes to form *p*-nitrophenol or one of its congeners. Such hydrolysis is a detoxification reaction of the original compound whether it occurs in the body, in the laboratory, or in nature. However, *p*-nitrophenol is also toxic; the most toxic of the three nitrophenol isomers. The intravenous lethal dose of *p*-nitrophenol in dogs is about 10 mg. per kg. of body weight. Animal experiments show central nervous system depression, methemoglobinemia, and hyperthermia as a result of exposure to *p*-nitrophenol. While toxic, this hydrolysis product of parathion is probably less toxic to warm blooded animals than is the original parathion molecule.

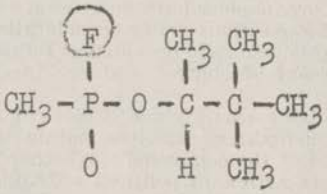
As indicated above, we believe all the "extreme-toxicity-to-mammals" nerve gases to be or to be among those organophosphates which contain either F or CN substitutes. The toxicity of some of their hydrolysis products seem to be related to these substitutes. Thus:



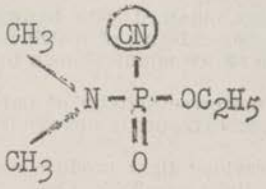
Sarin or GB



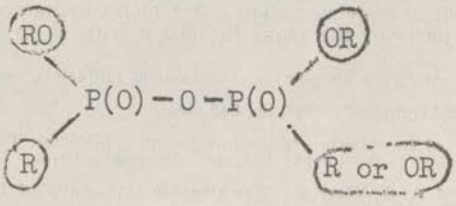
or



Soman or GD



Tabun or GA



(where R may be a fluoride or an alkyl fluoride)

VE or VX

The above "probable" structural formula for VX may not be correct. The true structure, as well as its decomposition products, is classified. The "probable" structure is that obtained from "Chemical Warfare" by Julian Robinson in Science Journal (vol. 3, No. 4, April 1967).

The Army and Air Force Technical Manual; "Military Chemistry and Chemical Agents," December 1963, from which most of the above structured formulas are taken, states that tabun reacts slowly with water and that its half life is 7 hours at pH 4 to 5. The hydrolysis products are "HCN and other products." Sarin and Soman, both of which contain F (fluorine), have rates of hydrolysis which vary with pH and which are very rapid in alkaline solutions. The half life of Sarin is stated as 7.5 hours at pH 1.8 and as 30 hours in an unbuffered solution. The hydrolysis products of Sarin are "HF under acid conditions * * *" and of Soman also "essentially HF."

For what it is worth as a matter of concern in this question, product HF is hydrofluoric acid. This is, of course, a toxic, irritating, and corrosive substance. Even brief exposures to 50 to 250 p.p.m. in air are dangerous.[3] [4] Similarly, HCN, a hydrolysis product of Sarin, is hydrocyanic acid. This is a true protoplasmic poison. Exposure to 100 to 200 p.p.m. in air for periods of 30 to 60 minutes can cause death.[5] Ironically, HCN vapors, too, are a war gas when so employed.

The possible similarity of VX and its degradation products to the other nerve gases, rather than necessarily to the organophosphorus insecticides, may reside in the fact that, except for the lower volatility of VX, the time of appearance of casualties by absorption through the skin is roughly the same at the same dose level with both V and G agents. In addition, the decontamination procedure is similar for the V and G agents, namely by application of chemical bases—bleach slurry, soapy water, alkali solutions, ammonia, "DS_2," et cetera.

A review of four books on organophopshorus compounds[6] turns up a number of interesting statements about the organophosphates in general and the behavior of these substances as related to the questions under consideration in this brief commentary. A selection of these statements are provided as follows with the admonition that they are presented out of context and are therefore not self-interpreting:

"Recently there has become available (mainly via "Chemical Abstracts") an enormous amount of Russian work on organophosphates, mainly upon the chemistry and simple biological properties of the compounds. Whether this liberalization is a consequence of the Western action, of political softening, or simply of the feeling that in an atomic age, organophosphates are mere toys we can (as usual) only guess." A. pp. 6–7.

"Another effect unexpected from simple inductive considerations is the ready hydrolyzability of Tabun. Heath points out that this compound is hydrolyzed 10^7 times as fast as paraoxon" (A. p. 36).

"More striking effects have been obtained with hydroxamic acids. Hackley *et al* studied more than 30 of these acids, all of which reduced the half-life of Sarin from the uncatalyzed value of 300 minutes down to from 1 to 7 minutes" (A. p. 44).

"The increase in the anticholinesterese activity of parathion upon exposure due to daylight. and even more upon exposure to ultraviolet light is probably due to isomerization" (A. p. 54).

"Usually, both visible and ultraviolet light produce compounds more potent than their parents in inhibiting cholinisterase" (A. p. 68).

"Exceptions to the rule that hydrolysis equal degradation may occur if the molecule has an ester link so arranged that on hydrolysis the alcoholic hydroxyl is on the phosphorus-containing moiety, e.g., Dipterex. In this case hydrolysis in fact enhances the anticholinesterase potency of the molecule" (A. p. 117).

"Bennett has defined systemic action * * * as involving absorption and translocation to other parts of the plant in such a way as to render those parts

---

[3] Sax, N. Irving, "Dangerous Properties of Industrial Materials," second ed., 1963, Reinhold, p. 884.

[4] "The Merck Index," eighth ed., 1968, pp. 543–544.

[5] Sax, op. cit., p. 884.

[6] A. O'Brien, Richard D., "Toxic Phosphorus Esters," Academic Press, New York, 1960.
B. Heath, D. F., "Organophosphorus Poisons," Pergamon Press, New York and London, 1961.
C. Kirby, A. J. and S. G. Warren, "The Organic Chemistry of Phosphorus," Elsevier Publishing Co., New York and London, 1967.
D. Chichester, C. O., ed., "Research in Pesticides," Academic Press, New York, 1965.

insecticidal. * * * A further classification of systematic insecticides has been proposed by Ripper: (a) stable: compounds not metabolized in the plant, (b) endolytic: compounds which are degraded and not activated in the plant so that the only toxic substance * * * is the parent compound, and (c) endometatoxic: compounds subject to activation by the plant as well as degradation, so that insecticidal materials other than the parent compound are present in the plant" (A. p. 289).

"Hydrolysis is a very general reaction. Every acid anhydrid, amide, or ester bond in every pentacovalent phosphorus compound so far studied, whether it is biochemically active or not, can be hydrolysed * * * In the hydrolysis of Tabun, as in the hydrolysis of many other compounds, several reactions take place at the same time, and the relative rates depend on pH" (B. p. 72).

"* * * the breaking of any one phosphorus bond by hydrolysis destroys the actual or potential biochemical activity of the phosphorus moiety. Hydrolysis is indeed closely related to biochemical detoxication reactions * * * the first stage of hydrolysis destroys the toxic properties of the compounds" (B. p. 82).

"The products of the first stage of hydrolysis are still esters or amides of acids of phosphorus, and can be hydrolyzed. They are acids, the anions of which are stable, whereas the free acids are not. In alkaline solution, therefore further hydrolysis takes place very slowly, but in acid solution it takes place rapidly. In neutral solution dialkyl hydrogen phosphates are completely ionized, and are stable" (B. p. 74).

"Isolated soil bacteria metabolize * * * Parathion-Me, Chlorthion, Trolene, Schradan and Dimefox * * * the main reaction in every case is hydrolysis. Under the conditions of the experiment about half of every compound * * * was hydrolyzed in 8 days" (B. p. 254).

"Plant enzymes do not catalyse the hydrolysis of phosphorus compounds very greatly but they do catalyse their oxidation. The oxidation products consequently accumulate more in plants than in animals * * * Oxidation increases both the water-solubility and anti-ChE activity. High water solubility is necessary if a compound is to be readily translocated. Oxidation, therefore, converts several deep-acting insecticides into systemic ones * * * untreated parts of a plant may become toxic through systemic action (translocation of the poison from the point of absorption or application to another part of the plant)" (B. p. 294).

"Sarin * * * does not react with water at 25 and pH7. * * *" (C. p. 319).

"Let me cite two types of interaction of pesticides which have been reported in the last 10 years * * * the first type * * * involves the potentiation between two organophosphates, EPN and malathion * * * the second type, which has recently attracted the attention of dozens of investigators, involves antagonism and potentiation between chlorinated hydrocarbons and organophosphates,[1] (D. pp. 70–71).

"The significance of this type of potentiation is obvious. From an industrial point of view, the use of potentiating compounds could conceivably give rise to unforeseen accidents * * *. The discovery of potentiation of one phosphate by another has given us an insight into a biological lesion that we had overlooked. We now know that some of these compounds inhibit aliesterases at a much lower level than they inhibit cholinesterase"[2] (D. p. 76).

The above quotations are intended to supply a sampling of facts concerning the extreme complexity of problems associated with organophosphate compounds and their ultimate fate in the environment. The quotations in total demonstrate that each compound is a problem unto itself. One cannot generalize from organophosphates as a class of compounds except that they are a class of compounds. Nor can one safely predict from unavailable information about VX where and

---

[1] Ball, W. L., et al. (1954), "Canadian Journal of Biochemistry and Physiology," vol. 32, pp. 440–445.
Rosenberg, P. and Coon, J. M. (1958), "Proceedings of the Society for Experimental Biology and Medicine," vol. 98, pp. 650–652.
Triolo, A. J., and Coon, J. M. (1963), "Federation Proceedings," vol. 22, p. 189 (abstract).
——— (Mar. 10–12, 1969), abstracts of papers presented at the Society of Toxicology, eighth annual meeting, Williamsburg, Va.

[2] In discussing this matter with Dr. Donald Spencer of the National Agricultural Chemical Association, we were informed that exposure to very low levels of organophosphates might indeed inhibit the aliphatic esterases, the result of which would change the protective enzymes of the body against insult by other chemical compounds.

for how long its residues will remain in the environment and with what effect, from knowledge about the organophosphates in general or the other nerve agents in particular.

If the Army's knowledge of VX and its residues in nature is not comparable to that which contemporary science has developed and is developing concerning the organophosphate and chlorinated hydrocarbon pesticides, then it must be relying upon the fact that it is releasing relatively small amounts of chemicals during each test—that the test environment is isolated and controlled—that the agents can be contained within the test environment—and that mixing and dilution provide the remaining margin of safety. The analogs of the above also apply in part to the disposal of chemical stockpiles by burial at sea.

If we may be of further assistance, please do not hesitate to call on us.

FREEMAN H. QUIMBY,
Specialist, Life Sciences,
Legislative Reference Service, Library of Congress.

○