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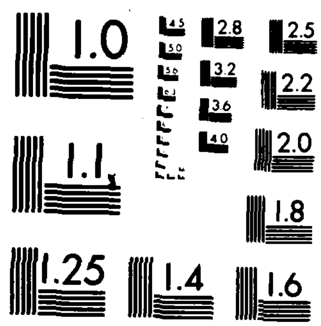

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APPRAISAL OF SCIENTIFIC RESOURCES FOR EMERGENCY MANAGEMENT

FINAL REPORT

Midwest Research Institute
Kansas City, Missouri 64110

For

Office of Research
National Preparedness Program Directorate
Federal Emergency Management Agency
Washington, D.C. 20472

FEMA Contract No. EMW-C-0835
FEMA Work Unit No. 9211A

September 1983

APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED

APPRAISAL OF SCIENTIFIC RESOURCES FOR EMERGENCY MANAGEMENT

by

Edward W. Lawless
Deborah M. Smith

Midwest Research Institute
Kansas City, Missouri 64110

MRI Project No. 7541-D

FINAL REPORT
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SUMMARY

An assessment of the scientific and technological information aspects of the Federal Emergency Management Agency found that agency has substantial capabilities and resources for meeting its needs, but also found several areas in which improvements appear to be possible, and developed several recommendations for making improvements. This assessment included a combination of approaches for determining FEMA's needs, capabilities and resources. One input was a review of the literature on informational needs and resources for emergency and disaster response agencies. Several previous studies had examined various aspects of these needs and resources and suggested methods for improving the exchange and accessibility of technological information under several circumstances, e.g., data bases, a clearinghouse, and establishment of FEMA.

A second input was a series of 12 selected case studies: five involved previous disasters of natural origin (hurricane, tornado, volcano, and heat wave); two involved emergencies from complex biological/technological interactions (the Legionnaire's Disease and the Medfly incidents); three involved major failures of electrical power production/distribution systems (one resulting from lightning strikes, one from protective devices in the grid distribution system, and one from a nuclear power plant accident); one involved hazardous waste disposal problems; and finally two involved wartime scenarios, one focusing on confrontation with a small power and one with a major (nuclear capability) power.

These case studies demonstrated that a wide range of needs exist for scientific and technological information, expertise and resources in emergency and disaster preparedness and response, mitigation and recovery. Rapid response to these needs is often necessary for effective decision making and resolution of the problems posed by an emergency, particularly those posed by complex modern technologies. These cases also revealed as a common characteristic the need for effective communication between federal emergency response officials and state and local agencies or parties-at-interest, with the media and with the public.

A third input was a series of surveys and interviews with selected FEMA staff regarding capabilities, practices and needs for scientific and technological information related to emergency and disaster preparedness and response. The survey focused on three parts of the FEMA organization: the National Preparedness Program Directorate; the State and Local Programs and Support Directorate; and the 10 Regional Offices. A fourth input to the assessment was a number of contacts with several other government agencies and private sector resources involved in emergency and disaster response.

The survey responses, interviews and other contacts found that the FEMA staff has a wide range of scientific, engineering and other technological expertise. The staff also has available to it outside assistance such as those available through FEMA contracting and consulting arrangements,

the National Defense Executive Reserve, the Federal Laboratory Consortium, and to some extent individuals in other federal agencies or in the private sector. FEMA's capabilities and resources are not, however, completely recognized throughout the agency. In part this arises because FEMA is a relatively new organization, in which organizational components and individual staff members have been drawn from several resources, in part because of the substantial range in interests of the different offices and branches of the organization, and in part because the substantial portion of the staff located in regional offices have had minimal opportunity for interaction with each other or with headquarters staff.

Currently FEMA staff appear to obtain scientific and technological input when needed from outside sources through three or four principal routes: (a) literature resources, (b) contractual arrangements; (c) other government agencies with a mandate to work in a closely related area; and (d) a fairly extensive set of personal acquaintances and referrals between FEMA staff and other federal agencies or private sector experts.

Many FEMA staff members seem to feel that their needs for scientific and technological information are being satisfactorily met by these existing routes. In contrast other staff members and some non-FEMA researchers in the disaster and emergency response field suggest that the full need is often not recognized by many FEMA staff members themselves, a large percentage of which have little background in the physical, biological, medical, or environmental sciences. Still other staff members feel that the major unmet needs are in the areas of behavioral science and in knowledge of state and local governments, and in how to work effectively with them. Interestingly enough, the need for scientific and technological expertise may be greater in the day-to-day planning activities of FEMA staff members in Headquarters than in immediate disaster and emergency response situations. FEMA Regional Office staff may need assistance the most when emergencies evolve from complex technologies rather than from natural forces.

One must conclude that the needs probably vary substantially between different units and different positions within FEMA. Some individuals have by education, experience or personal contacts, access to scientific and technical information needed to perform their duties. Others, however, have inadequate access to such resources and the mechanisms available within FEMA should be improved to remedy this situation.

Five options are suggested for improving FEMA's scientific and technological information capabilities to meet its needs. These include: (a) improving the presently existing system of personal contacts; (b) improving directories of emergency and disaster response resources; (c) developing a Science Resource Information System; (d) developing a National Emergency Science Reserve; and (e) preparing critical reviews of available information in selected areas. Each of these is discussed briefly below.

Personal Contacts System: The effectiveness of a personal contact system within FEMA could be improved significantly by several means. These include holding a series of intra- and inter-unit (directorates, offices, divisions, branches) technical meetings, seminars, conferences, etc. Such meetings may be particularly helpful to staff members in the Regional Offices, who, in turn may have greater knowledge of the requirements for working effectively with state and local governments and with the public, and could share this knowledge with Headquarters staff. Such meetings should combine considerable opportunity for informal personal interactions as well as more formal discussions of problems and activities of mutual interest. These meetings may be much more effective in transferring information about lessons learned during an event than would a typical report of it filed in headquarters.

Directories of Government Resources: The FEMA staff could benefit significantly from greater awareness of the Federal Laboratory Consortium Directory and the resources available through the FLC. The staff may benefit even more from having available an Emergency Management Information Sources Directory, with fully indexed information on government agencies, centers, facilities and programs engaged in work related to FEMA's needs.

Science Resource Information System: A carefully designed computerized Science Resource Information System could be of much help to FEMA staff members who need quick assistance on specific problems. Reasonable compromises must be made between comprehensiveness and ease of use in designing the SRIS. To be widely used, an information system must be fast and flexible and offer distinct advantages over existing practices. Compatibility with other information systems may also be critically important. The SRIS would augment--not replace--current FEMA practices. The detailed development of a SRIS is beyond the scope of the present project, but several suggested criteria for it can be briefly summarized as follows.

A multivariate or multimatrix analysis of parameters may be helpful in deciding what information to include in the computerized data base and how it can be searched. A primary parameter is the general type of emergency, which may be characterized by the nature of the trigger event, e.g., the different kinds of identifiable natural and technological hazards or wartime situations would comprise a substantial list of fields for coding. These kinds of situations would require different kinds of responses with different kinds of needs for scientific and technological information or expertise. The types of responses may be narrowed by establishing constraints peculiar to the specific event. Similarly the kinds of information or expertise to be sought may be constrained by several factors. The identification and characterization of the science information resources are the most critical elements in the system. These resources may include library resources, knowledgeable personal contacts (inside or outside of FEMA) and other outside experts. Compatibility with a computer retrievable information system for emergency response equipment may be advantageous. Individuals must be identifiable by discipline, specialties, geographical location and FEMA Region, kind of permanent position (e.g, FEMA, other government agency, university, industry), type of availability (e.g., telephone contact or on-site resource); how soon available; how long available; existing or prior contractual or consulting arrangements; and addresses and telephone number. Of particular value may be an easy way to identify those with special broad abilities in field expediency. Information on individuals must then be cross coded with emergency response needs.

After the SRIS has been designed a sizable effort will be required to identify those individuals and other resources for which data are collected and encoded. Hard decisions must then be made on how many and on whom of the identified sources that data will be compiled and encoded. A tier system may be cost effective, i.e., complete information may be collected for a core group of those most likely to be used, less information on those likely to be used less frequently, and only certain basic information on all others in the system. The data base must be reliable and up-to-date if it is to be useful and used. New types of emergencies may need to be added from time to time as well as new response patterns and procedures, and new disciplines and specialists. Systematic procedures will be needed to keep information on individuals up-to-date. Pertinent research reports and selected technical journals might be monitored to add significant entries to the data base.

National Emergency Science Reserve: Several mechanisms are available to be used by FEMA for obtaining the services of scientists and engineers in the private sector on short notice. One approach would be the establishment of a National Emergency Science Reserve. The NESR would be modeled after the NDER, and the Disaster Reservist Program of the FEMA Regional Offices. It would establish working relationships with both active and retired scientists. They would receive orientation in FEMA's needs and would have completed the necessary consulting and contractual agreements on a contingency basis to enable quick access to their expertise in emergencies.

Critical Reviews of Available Information: Considerable documentation exists relating to emergency and disaster preparedness and response. Considerable effort, however, would be required by FEMA staff receiving responsibilities in new areas to become familiar with prior results in those areas. Accessibility to the available information could be improved considerably. A carefully selected and prepared series of up-to-date critical reviews and state-of-the-art reports of many topic areas in this literature would be valuable assets for FEMA staff and for state and local government employees with emergency responsibilities. Examples might include fire protection research, radiological protection from nuclear power plant accidents, concepts and operation of public shelters, and post attack sanitation measures, to name but a few. A set of documents that integrate the available information and lessons learned on given subjects will be more useful than a large number of reports on separate incidents or research projects.

A special collection of case histories of previous related emergencies would be of value to many authorities at the scene of natural and technological disasters. These detailed case histories would be selected to illustrate a wide range of problems that can arise in emergency management, and both more successful and less successful efforts to resolve them.

The collected volume should be extensively indexed. Such a collection would appear to be increasingly valuable as FEMA becomes more frequently involved in emergencies and disasters of man-made, technological origin, particularly if terrorists, saboteurs or vandals strike against complex technologies that affect thousands of lives.

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The scientific and technological information needs, capabilities and resources of the Federal Emergency Management Agency were evaluated through a combination of approaches. These included: a review of prior research on the informational needs of emergency and disaster response agencies; case
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20. ABSTRACT

studies of selected previous disasters and emergencies; analyses of FEMA's mission and roles; surveys and interviews with selected FEMA staff regarding capabilities, practices and needs; and contacts with several other government agency and private sector resources involved in emergency and disaster responses.

Twelve case studies are included: (1) Hurricane Camille, 1969; (2) Hurricane Agnes, 1972; (3) Omaha Tornado, 1975; (4) Mt. St. Helens Eruption, 1980; (5) Kansas City Heat Wave, 1980; (6) Legionnaire's Disease, 1976; (7) Medfly Controversy, 1981; (8) Northeast Power Failure, 1965; (9) New York City Blackout, 1977; (10) Love Canal Disaster, 1979; (11) Three Mile Island Reactor Failure, 1979; and (12) two Wartime Scenarios: (a) Terrorism, Sabotage and Vandalism, and (b) Nuclear Confrontation.

The scientific and technological information, expertise and resources varied considerably among the cases, but were important in the resolution of several, particularly those involving technology-related hazards. Communications skills and an ability to work with local and state groups were important to those "in charge" of the resolution in every case.

The survey of capabilities and needs focused on three parts of the FEMA organization: the National Preparedness Program Directorate; the State and Local Programs and Support Directorate; and the 10 Regional Offices. The FEMA staff has a wide range of scientific, engineering and other technological expertise. The staff also has available to it outside assistance such as those available through FEMA contracting and consulting arrangements, the National Defense Executive Reserve, the Federal Laboratory Consortium, and to some extent individuals in other federal agencies or in the private sector. FEMA's capabilities and resources are not, however, completely recognized throughout the agency. In part this arises because FEMA is a relatively new organization, in which organizational components and individual staff members have been drawn from several sources, in part because of the substantial range in interests of the different offices and branches of the organization, and in part because the substantial portion of the staff located in regional offices have had minimal opportunity for interaction with each other or with headquarters staff.

Several options are suggested for improving FEMA's scientific and technological information capabilities to meet its needs. These include: improving the presently existing system of personal contacts; improving directories of emergency and disaster response resources; developing a Science Resource Information System; developing a National Emergency Science Reserve; and preparing critical reviews of available information in selected areas.

PREFACE

The Federal Emergency Management Agency recognizes the needs of civil emergency and disaster response officials for rapid access to scientific information and advice during times of crisis. It further recognizes that these needs are being only partially met at present, and that an improved system of meeting these needs is desirable. The Office of Research of the National Preparedness Program Directorate of FEMA contracted with Midwest Research Institute for a study of the scientific input needs of emergency/disaster response agencies, of how those needs have been met historically, and of ways that they could be met better in the future. Dr. Herman Weisman, Office of Research, was Project Officer for this study, Contract No. EMW-C-0835, "Scientific Guidance To Emergency Organizations."

This report presents the results of this short study, which was designed to appraise the needs and to suggest alternative approaches to meeting the needs, but not to develop a detailed program. This report was prepared by Dr. Edward W. Lawless and Ms. Deborah M. Smith. Assisting on the project team were Mr. Richard O. Welch (initially on the MRI staff and later a project consultant), Mr. Francis X. Tobin (consultant, and formerly FEMA Director, Region VII), and Mr. James Bergfalk (consultant and formerly Principal Regional Official of the U.S. Department of Health and Human Services, Region VII). This study was MRI Project No. 7541-D

MRI thanks all those persons who contributed information to the project through surveys and interviews.

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I. INTRODUCTION

The Federal Emergency Management Agency was established in 1979 to serve as a focal point for federal efforts in the management of emergencies and disasters. FEMA serves a coordination role for all federal efforts involving preparedness, mitigation, response, and recovery for all kinds of disasters and emergencies, including natural and technological disasters, major civil disorders, and civilian response in event of the threat of nuclear attack. FEMA and its predecessor agencies have long recognized the many needs for scientific and technical expertise and guidance in dealing with disasters and emergencies. Several steps have been taken to meet these needs, but the diversity of needs created by different kinds of emergencies, the immediacy of the need for assistance that often arises and several recent examples suggest strongly that an improved system is desirable.

II. OBJECTIVES, APPROACH AND REPORT ORGANIZATION

The objectives of this study were to assess the needs for scientific information and resources in the FEMA emergency structure (other than for continuity of government), and the systems being used to meet those needs. A further objective was to devise means of better meeting needs that were not being adequately met by present systems.

The scope of work of the contract for this study specified three tasks as follows:

1. Literature Search - The contractor shall conduct a literature search that examines historical examples of systems for scientific input to emergency organizations and studies of related topics.

2. Needs Appraisal - The contractor shall examine FEMA roles, missions, and staffing patterns (other than for continuity of government) to detect potential need for scientific input, and the in-house capability to supply same (at both the national and regional levels).

3. Synthesis - The contractor shall describe and evaluate alternative means (man power and resources) for meeting whatever needs or short falls may be established in Task 2.

FEMA's needs were therefore assessed through a combination of preparation of several selected case histories, interviews and surveys of FEMA personnel in Washington, D.C., and in the regional offices, and contacts with a small number of persons in state and local government and in the private sector.

The remainder of this report contains: Chapter III, a brief background summary of previous studies of the science and technology information needs of emergency management organization; Chapter IV, a set of ten brief case studies of government response to emergency situations, examining particularly the systems of scientific inputs and guidance that emergency response organizations used or needed; Chapter V, an appraisal of FEMA's science information needs; Chapter VI an outline of options for meeting needs; and Chapter VII, Summary. Appendices provides a list of contacts outside of FEMA Headquarters and a copy of the survey instrument used.

III. BACKGROUND

Natural hazards of many kinds have always threatened mankind's safety, activities and structures. Particularly threatening were atmospheric perturbations, producing stifling heat and drought, unseasonable frosts and numbing cold, isolating snow, damaging sleet and hail, ravaging floods from severe storms and hurricanes, devastating winds from tornadoes, and potentially fatal lightning strikes. Only slightly less threatening were the more rare perturbations of the earth, volcanoes, and earthquakes, (including tidal waves), while in many areas the greatest threats were from other biological organisms, e.g., epidemics of disease, plagues of insects, etc. Fires in buildings, prairies and forests (which could arise from either natural or anthropogenic causes) were yet another major cause of concern. Before 1900, these hazards were addressed largely in a reactive manner (after the disaster had occurred) and primarily at the local level (either volunteer groups or local and state governments). Some private organizations of national or international scope (such as the Red Cross, several churches, etc.) assisted in responding to major disasters, and industry organizations were formed to improve the safety of certain new technologies, e.g., the railroads.

The first half of this century saw an increasing realization that science and technology could be used to prepare for such threats and to mitigate the damages they cause. Increasingly also, the federal government began to take an active role in using science and technology for these purposes. Thus, the U.S. Department of Agriculture began research on pest plagues, the Public Health Service on epidemic diseases, the Bureau of Mines on mine safety and warning agents for natural and city gas, and the Corps of Engineers assisted in levee construction. All of these programs had valuable results. The accomplishments of the World War II Manhattan Project (in developing the atomic bomb) and the later space projects of the Department of Defense and the National Aeronautics and Space Administration (in putting a satellite into earth orbit and subsequently in putting a man on the moon) taught further lessons. They demonstrated clearly the value of systematically applying huge teams (of scientists, engineers, support groups and technical information) towards complex and difficult but clearly defined goals.

The post World War II development of nuclear weapons by the U.S.S.R. and the intercontinental missiles to deliver them against the United States raised new threats to military installations, industrial facilities and our cities. Increasing attention was given during the 1950's and early 1960's to the questions of how to protect large civilian populations during and following an attack with nuclear, chemical or biological weapons. This effort was led by the federal government, since state and local governments had little scientific expertise in this new problem area.*

* The Federal Civil Defense Act was passed in 1950. It established the Federal Disaster Assistance Administration, one of the predecessor agencies of FEMA.

The rise of organized civil disorders and terrorism in the late 1960's and 1970's has been another factor that has changed the concepts of emergency response. Again the federal government was often in the forefront of research to combat such threats, because the scale of organization was so large or the technological component so new or complex that local authorities were at a serious disadvantage.

The evolving role of science and technology in emergency management was recently reviewed by a committee of the National Resource Council.[1] As early as 1958, the National Academy of Sciences had been asked by the government to assess the civil defense research needs in the fields of engineering, radiation physics, biomedicine and social sciences.[2] In 1963, the NAS assessed[3] for the Office of Civil Defense, DOD, the civilian problems that might be associated with an enemy attack, including those of the political and psychological impacts and public acceptance of alternative CD education, training and other preparedness programs, as well as those for immediate survival and post-attack recovery.*

The occurrence of the Great Alaska Earthquake near Anchorage in 1964 had a major galvanizing action in bringing the federal government into the natural hazards area. Increasingly often, similarities have been seen between the response problems, scientific inputs and research needs for various kinds of disasters and emergencies, whether they arise from natural sources, technological accidents, or civil defense needs.

A 1967 NAS study by Ayres[5] for the Office of Emergency Planning reviewed federal emergency planning research, noted that peacetime disasters have a much higher chance of occurring than wartime emergencies, but were receiving much less (and inadequate) attention. He recommended increased attention to developing and using technical information systems and data bases. A 1969 NAS civil defense study[6] recommended that CD research and other programs for handling peacetime types of emergencies should be related to those for responding to nuclear attack, and that these should be integrated from the local to the national level.

In 1971, Fritz, at the Institute of Defense Analysis, reviewed[7] emergency research programs, noted deficiencies in information availability and discussed the problems associated with establishing an emergency preparedness research clearinghouse.**

The Office of Emergency Preparedness, Executive Office of the President made a comprehensive study of natural hazards, culminating in a 1972 report to the Congress.[8] It examined the application of science and

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* A major 1967 symposium reviewed the issues in and state of the art of post-attack recovery from nuclear warfare.[4]

** The Office of Emergency Preparedness took steps to initiate such a clearinghouse, but was dissolved in a reorganization in 1973.

technology to disaster preparedness, prevention and mitigation; the conclusions emphasized the need to make better use of existing information and resources and the desirability of using interdisciplinary approaches to disaster research. In 1975, White and Haas of the University of Colorado published the results of a study of natural hazards research and applications.[9] They found too much emphasis on finding technical solutions to problems and not enough on determining the economic, social and political factors that aided or hindered the implementation of those solutions or caused perpetuation (or even an increase) of the problem despite implementation of an anticipated solution. Their recommendations included a clearinghouse service to provide rapid, efficient interchange of information between hazard researchers and those who must plan for or react to disasters (e.g., at the state and local level).*

In 1975, the Federal Disaster Assistance Administration, Department of Housing and Urban Development published a directory[13] that summarized the disaster-related research of the early 1970's to improve the exchange of technological information for mitigating disasters (particularly information related to building design, construction and location).

The National Governors Association conducted studies during 1977-1978 of the states' degree of preparedness for and problems in managing emergencies of all types. These studies[14] found that most state and local emergency and disaster programs were too fragmented and poorly coordinated for good planning and management. They also found that many state and federal officials believed that better planning and management could save many lives and dollars, and that the states should better utilize their resources and personnel to deal with man-made emergencies. The NGA recommended the adoption of a Comprehensive Emergency Management (CEM) concept for dealing with emergencies of five different types.

1. Attack by Conventional or Nuclear Weapons
2. Internal Disturbances
3. Natural Disasters
4. Technological Emergencies
5. Energy and Materials Shortages

The NGA recommended that the state emergency organizations should develop programs and operational guidelines for preparedness, response, mitigation, and recovery for each of these types of emergencies. The NGA further identified a need for better communication links between governments at all levels and with the private sector, to provide up-to-date information on technical and managerial aspects of CEM. A central information clearinghouse was recommended.

* This study was recently updated,[10] but the major conclusions remain. Lander et al.[11] and Tubbesing[12] have recently compiled information on data sources on natural hazards.

In addition, the NGA recommended the establishment of a Federal Emergency Management Agency, in which would be combined the responsibilities of the Federal Disaster Assistance Administration, the Federal Preparedness Agency, and the Defense Civil Preparedness Agency. In particular, the NGA recommended that FEMA and other federal officials stationed in regional offices should be trained in and oriented toward the methods, resources and problems of state governments, and that FEMA should provide funds to train and orient state and local officials in the CEM concept. These recommendations of the NGA were generally accepted by the President and the Congress in the establishment of FEMA in 1979.

The recent NRC committee study of the role of science and technology in emergency management was conducted for FEMA.[1] Four of its conclusions and recommendations based on previous studies, are pertinent to the present study. These may be summarized as follows:

- There is a clear need to use available scientific and technical information more effectively in emergency mitigation, preparedness, response, and recovery programs and operations.

- More effective use of science and technology by the emergency management system requires improvements in access to and the transfer of existing knowledge.

- A system is needed whereby emergency managers at all levels, and especially at the local level, can have direct and rapid access to scientific and technical experts in a wide range of fields and disciplines.

- Components of such a system might include a computerized data bank, a clearinghouse, or other relevant information systems. These could provide mechanisms for FEMA headquarters and regional officials and state and local authorities to identify and contact individuals in government, industry, educational institutions, and professional or public interest groups that could help resolve immediate problems and questions arising from an emergency or disaster.

The NRC report[1] did not attempt to identify and analyze the needs and resources for specific kinds of expertise, or the current mechanisms for making existing resources available. Such assessments are, however, objectives of the present study, which also assesses potentially better systems for meeting present needs.

IV. CASE STUDIES OF EMERGENCY RESPONSE

This chapter presents brief synopses of 12 cases involving responses by public officials to disasters and emergencies, focusing particularly on the scientific information needs of each. Case selection was necessarily somewhat arbitrary, the total number of such cases being very large[15-19] and increasing almost weekly. Our cases have all occurred since 1965, and include emergencies arising both from natural and anthropogenic causes. They represent much of the range of response situations faced by FEMA.

A. Individual Case Histories

The first two cases involve Hurricanes Camille (which struck the Gulf coast in 1969) and Agnes (which caused great flooding in the mid-Atlantic states in 1972). They had rather different impacts, but are typical of the problems that involve FEMA now. The next three cases also involve natural disasters: the Omaha (Nebraska) tornado of 1975; the Mount St. Helens (Washington) eruption of 1980; and the Midwest heat wave of 1980 (with a focus on the effects and response in Kansas City, Missouri).

The 6th case, the so-called Legionaire's Disease epidemic of 1976, involved a natural disease organism that was relatively innocuous until amplified in a favorable technological setting. Similarly, the 7th case arose from a natural organism, the destructive Mediterranean fruit fly; it focuses on the controversy over the appropriate technological response to a 1981 outbreak in California.

The 8th and 9th cases both involve electrical power failures in the heavily populated areas of the Northeastern United States. The 1965 blackout was caused by an unanticipated reaction to an overload of the safety systems in a giant grid of electrical transmission lines and power-plants, while the 1977 blackout of New York City resulted when lightning initiated somewhat similar reactions. These cases are important because of the essential nature of the power supply in times of national emergency.

The 10th case is the disaster that befell families living in the former Love Canal area at Niagara Falls, New York, when previously buried chemical wastes there surfaced and forced evacuation from their homes in 1978 and 1979. Such health-threatening discoveries have become increasingly frequent, and are becoming a major national problem. The 11th case similarly involves a major technological error, the series of events that shut down Reactor No. 2 at the Three Mile Island nuclear power plant in Pennsyvania in 1979, and for a time threatened to require evacuation of a large population from nearby areas. The TMI incident has fueled a continuing controversy over the safety of these plants and extent of emergency response measures needed.

Case No. 12 involves two hypothetical wartime scenarios: one examines the scientific and technological information aspects of terrorism and vandalism that might occur in confrontation with a small foreign county, while the second considers aspects of a confrontation with a superpower with nuclear weapons capabilities.

Since these case histories were prepared with quite modest investment of resources to serve limited uses, they should not be viewed as a definitive treatment of any of the subjects.* Source materials for preparation of these case histories consisted variously of personal contacts, popular press articles and in a few cases the scientific literature. The primary personal contacts are listed in Appendices B and C.

CASE HISTORY NO. 1 - HURRICANE CAMILLE, 1969

Hurricane Camille occurred in August 1969. It hit Cuba first, then roared across the Gulf of Mexico and hit the mainland near Gulf Port, Mississippi, on August 19, 1969. Camille packed 190 mile per hour winds and caused 20-foot tides. The National Hurricane Center in Miami reported that Camille was the strongest hurricane in the United States since 1935 when it struck Mississippi. It devastated much of the central Gulf coast. The death toll in Mississippi, Louisiana, and Alabama coastal areas totaled 149 persons.

The storm continued its damage as torrential rains hit the mountainous areas of western central Virginia on August 20th. Sixty-seven persons died and 106 were missing after floods struck many towns. The James River crested 19.5 feet above the flood stage. Camille finally dissipated in the Atlantic on August 25.

President Nixon declared Mississippi a disaster area on August 18, 1969. He allocated $1 million in federal aid. Louisiana was declared a disaster area on August 19, also qualifying for federal aid. The Mutual Loss Research Bureau estimated that the insured losses from Hurricane Camile totaled $500 million. Much of the damaged property was not insured and officials further estimated total losses to reach $1 billion.

The major difficulty in the aftermath of Hurricane Camille was the lack of a useable communications system, according to the federal disaster coordinator in charge, Frances Tobin, later FEMA regional director in Region VII. Tobin said he was able to obtain radio equipment from military personnel to create a workable communication system in order to direct relief operations from a central headquarters. Transportation through the storm damaged area was also difficult, but Mr. Tobin said the Southern Pacific Railroad Company provided railcars to house operational headquarters and travel through the region.

* A book could be written on the TMI case alone.

The storm also brought on a rodent problem, Mr. Tobin said. He contacted the Center for Disease Control, who in turn sent officials to the area and worked with local health officials to control the pests.

Summary of Scientific Factors: Mr. Tobin reported that relatively little specialized scientific information was needed or sought during relief operations for Hurricane Camille. He said that this type of disaster demanded primarily coordination of resources and restoration of basic technical services. He said that with the assistance of local officials under federal management, services were restored relatively quickly, relief delivered and long-term assistance provided. This was not a disaster demanding unusual technical or scientific information, although it did require an additional communications system, health care specialists, and rodent control specialists.

CASE HISTORY NO. 2 - HURRICANE AGNES, 1972

Hurricane Agnes struck near Panama City, Florida, June 19, 1972, then proceeded up the east coast of the United States. For a full week, torrential rain and floods occurred. Hurricane Agnes was unique among tropical storms in meteorological history because it covered such extensive inland areas. The worst damage from Hurricane Agnes was in eastern Pennsylvania and southern New York State, where heavy rains the previous week had already made the area susceptible to flooding, but some damage occurred as far inland as Ohio. In all, the 5-day storm flooded 5,000 sq miles of land and forced the evacuation of 350,000 people from their homes.

The American Red Cross reported the dead and injured as follows: Florida - 8 dead, 36 hospitalized; Georgia - none dead, 1 hospitalized; Virginia - 13 dead, 9 hospitalized; West Virginia - none dead, 1 hospitalized; Washington, D.C., 2 dead, none hospitalized; Maryland - 20 dead, 6 hospitalized; Pennsylvania - 48 dead, 799 hospitalized; and New York - 31 dead, 118 hospitalized. The totals for all areas were 122 dead, 970 hospitalized. National officials said the figures were moderate considering the force of the storm. In addition, two hospitals in the Wilkes-Barres, Pennsylvania, area had to be evacuated. More than half of the 300 doctors in the area lost the facilities where they had practiced. Fifty out of 67 clinics were flooded.

According to a federal report prepared by the Office of Emergency Preparedness, more than 5,200 dwellings and mobile homes were destroyed and 126,250 families suffered losses of property or persons. This report also showed that 578 bridges were destroyed, 648 were damaged; 650 schools were damaged and/or destroyed. The Office of Emergency Preparedness showed damage estimates of $601 million to business and individuals; $404 million in public property damage; and $1 billion in residential and agricultural losses.

According to a report from the Office of Emergency Preparedness, the governors of Florida, Virginia, Maryland, Pennsylvania, and New York asked President Nixon to declare those states disaster areas on June 23, 1972. The governor of West Virginia made the same request on July 3rd and the governor of Ohio on July 19th. These requests were also granted.

The Office of Emergency Preparedness sent in a federal coordinating officer for each state. These officials were authorized to use personnel, equipment, supplies, and facilities, and to coordinate activities between federal and private relief agencies. Each state also had its own field office and individual assistance centers throughout the states for the victims. President Nixon also sent his own official from the Office of Management and Budget on August 12, 1972, to expedite relief assistance.

The four most immediate needs in the emergency phase of the damage left by Hurricane Agnes were: (1) to provide drinking water; (2) to deal with sanitation and sewage problems; (3) to restore electrical power; and (4) to provide for the injured and homeless. Additional problems were found in debris removal, utility restoration, transportation, flood control and irrigation repairs, and health care facility restoration.

Federal Disaster Assistance Administration officials brought in pumps, generators, water purifiers, water storage tanks, sanitation supplies, and communication equipment.

Health officials were concerned about the possibility of an outbreak of encephalitis. This possibility was averted after officials from the Center for Disease Control in Atlanta sprayed the area for mosquitoes which could spread the disease. Local government officials, the National Guard, the Red Cross, the Salvation Army, and volunteers filled the immediate needs for rescue, shelter, food, clothing, and medical care. The federal government used support from the Army, Navy, and Coast Guard to provide rescue workers and health and sanitation equipment. They also delivered air transportaton and communication equipment, and helped to evacuate more than 350,000 people.

The American Red Cross managed 688 shelters during the course of the disaster. They housed more than 178,000 people and fed more than 3 million meals. Their total contribution was estimated at more than $22 million. The Salvation Army made a similar contribution of more than $11 million in benefits.

Temporary housing provided a major problem for federal officials in managing this disaster. This is the most expensive and most difficult area of assistance. It was needed for more than 27,348 people. This number was unprecedented in the history of American disaster relief administration efforts. Primarily utilizing mobile homes, federal officials did the best they could for inhabitants. Victims of Hurricane Agnes were also eligible for Farm Home Administration and Small Business Administration loans, unemployment assistance, and special financial assistance provisions for the elderly.

Not enough trained personnel were available in some areas to complete necessary sanitation inspections for restaurants, retail food outlets, food warehouses, and pharmacies. All of these suppliers were prohibited from doing business until such inspections were made.

Summary of Scientific Factors: The management of Hurricane Agnes demanded several kinds of fairly familiar scientific and technological information. The most pressing problems left by the storm were restoration of drinking water, sanitation and sewage facilities, electrical power, prevention of outbreaks of disease (especially mosquitoe-borne encephalitis) and provision of housing. These were handled by the trained disaster relief administration officials, despite the magnitude of the storm damage and number of victims. Scientific information relating to potential flood levels came from the U.S. Army Corps of Engineers. The U.S. Weather Service also provided information on the direction of and potential additional damage of the storms, according to Robert J. Adamcik, now deputy regional director of FEMA, Region III in Philadelphia and director of disaster relief for Hurricane Agnes. The management of the effects of Hurricane Agnes provided valuable lessons for the management of other natural disasters.

CASE HISTORY NO. 3 - OMAHA TORNADO, 1975

On May 6, 1975, a tornado touched down at 4:28 p.m. and was on the ground 27 minutes in or near Omaha, Nebraska. The tornado made its initial touchdown in northwest Sarpy County and traveled north to northeast, cutting a path 1/4 mile wide and almost 9 miles long.

The tornado left three people dead, 110 people hospitalized, 129 treated at hospitals and released, and 323 homes destroyed. An additional 413 homes incurred major damage and another 1,038 homes had minor damage. Apartments and condominimums destroyed totaled 130, with an additional 208 having major damage and 142 having minor damage. More than 100 businesses suffered damage. The estimated total damages were: $13 million to residential property; $10.7 million to commercial property, $5.8 million to industrial plants; $600,000 in miscellaneous property, and $30.2 million in total real estate. In all, 7,350 people were affected.

The governor of Nebraska sought a federal disaster declaration. It was granted on May 7, 1975. Federal assistance was authorized for Omaha and the surrounding towns, and 1,500 members of the National Guard were mobilized for 12 days. Private assistance came from 20 mobile units and Douglas and Sarpy county REACT volunteers. The disaster recovery, including public, government, and emergency aid to individuals from both public and private sources, totaled $11.2 million.

Two press conferences were held, one on the day after the tornado and a second on the following day. The first one allowed officials to announce the President's declaration of disaster, qualifying area residences for relief; and the second gave out important supplemental information. Disaster centers opened on May 9. These operations went relatively smoothly with qualified staff. Media coverage promoted the centers as places where people could get help. The media coverage was considered outstanding, providing information for recovery in the assistance available.

On May 13, the mayor of Omaha announced that operations were running smoothly. Within a 7-day period, 80 percent of the damage had been cleaned up.

Shortly after the tornado, area residents formed a disaster review task force to develop recommendations for disaster planning to avert chaos and further damage. Among its recommendations were:

(1) A communications center should be developed in the city/county building to ensure rapid flow of information and improved communications.

(2) Disaster sirens should be sounded until an all-clear is issued.

(3) Local civil defense should be reorganized into one metropolitan agency.

(4) Public education should be improved concerning what to do during disasters and how to prevent additional damage.

According to the Mayor's Disaster Review Task Force, the warning systems of the city were considered good. The weather service, military and civilian, were considered excellent in notifying the public with accurate and timely information. A number of officials noted that the city most needed a central communications facility. Members of the media of the Omaha press, radio and television community and ham radio operators felt the same need. They said that a central communications facility would have provided better information more quickly. Some asked for an office inside the weather bureau. City and county civil defense officials also asked for an emergency communications system with ties to the police, fire, medical care, sheriff, and mass transit agencies, in order to notify the appropriate people in time of disaster.

Summary of Scientific Factors: Like Hurricanes Camille and Agnes, the Omaha Tornado was a natural disaster, but came with little warning. Disaster relief demanded relatively little scientific information outside the knowledge and experience of the federal coordinating officers. The primary and immediate objective was restoration of basic services and provision of food, clothing, and shelter for the victims. FEMA officials orchestrated relief efforts, and felt that relief needs were met competently. Effective communications with the affected population was essential and appears to have been met unusually well.

CASE HISTORY NO. 4 - MOUNT SAINT HELENS ERUPTION, 1980

Mount Saint Helens is a volcanic mountain located in southwestern Washington, 25 miles north of Portland, Oregon and 100 miles south of Seattle, Washington. Dormant since 1857, the volcano erupted on March 26, 1980, the first to erupt in the continental United States since 1917. The eruption sent a plume of volcanic ash and gases 15,000 feet in the air and set off minor mud slides and avalanches.

Authorities had received considerable warning of volcanic activity: small amounts of steam and ash had been emitting sporadically from two crescent-shaped faults across the summit of the mountain. Scientists had established several monitoring posts to follow the subterranean events. The first real eruption came after a week-long series of smaller earthquakes and explosions of smoke and ash. The quakes had registered an average of 4.0 on the Richter scale, and had occurred at a rate of 1 per hour, according to scientists from the University of Washington. By March 25, the earthquakes had increased to more than 60 per hour, indicative of the movement deep in the volcano of molten lava.

There was no serious damage reported from the March 26 eruption, and the rate of small earthquakes returned to 2 or 3 per day after the eruption. About 400 persons, primarily loggers and forest rangers and residents who lived high on the mountain, were ordered evacuated. Authorities also set up roadblocks to close off Mt. St. Helens above the timber line because of potential damage from avalanches triggered by the moving ground.

On May 18, 1980 an enormous eruption of Mt. St. Helens occurred. The volcanic lava blew the top off of the mountain's 9,677 foot summit, reducing the elevation of the volcano by several hundred feet and opening crevices more than a mile long and 1,700 feet deep. A plume of ash and steam went 60,000 feet into the sky, igniting lightning storms, and setting hugh forest fires. Super hot rock and gas swept down the slopes and flattened every tree for 120 square miles. Massive flows of ash, mud, melted snow, and debris poured down the Toutle River on the volcano's north side, destroying a saw mill, dozens of homes and cabins, and 10 bridges. Dark clouds and volcanic ash and dust blotted out the sun for an area within 160 miles around the volcano, and fallout occurred as far as 500 miles downwind.

By May 23, 19 persons were confirmed dead and an additional 77 were missing. Numerous deer, elk, and other wildlife were also reported dead. The water temperature rose to 100°F in the Toutle River, killing all its fish. The lumber industry suffered among the greatest damage, with losses of more than $200 million because of the thousands of giant trees that had been ripped out.

On May 19, 2,000 residents from the town of Toutle and other threatened outlying areas had been evacuated by Army and Air Force helicopters. Many communities in the eastern Washington, northern Idaho, and western Montana were closed because of drifting volcanic ash, which was up 7 feet deep in some spots. The volcanic ash reduced the visibility to near zero and forced closing of highways, airports, schools, and public offices. The ash also clogged roads and stranded motorists with drifts up to 3 to 4 feet high along the roadways. Many people were reported wearing masks for protection. On May 21, after President Carter flew out to inspect the damage Washington State was declared a disaster area.

Although Mt. St. Helens had several subsequent eruptions (including one on May 25), the May 18th eruption was its most violent. Scientists said it was caused by the buildup of pressures of gas and magma, the release of which may have been triggered by two earthquakes measuring nearly 5.0 on the Richter scale one minute before the explosion. The eruption on May 18 had the force equivalent to that of 10 million tons of dynamite, 500 times that of the Hiroshima atomic bomb, according to the National Oceanographic and Atmospheric Administration. The thrust of the gas and volcanic ash floated upward and eastward from May 19 until May 21, then drifted and spread to the east. The eruptions on May 18 and 25 covered more than 12,000 square miles with ash and debris. After these eruptions, federal scientists and officials said that it was unlikely that the fallout would further affect human health, livestock, or crops.

By July 4, 25 persons were confirmed dead and 40 were still missing and feared dead. The economic damage to the area was estimated as $2.7 billion. The losses in timber on federal lands were reported at $500 million. The cost of reforestation to the damaged lands and fish and wildlife replacement was at least $300 million. Agricultural losses were estimated at more than $260 million; equipment and dam loss at $20 million; bridges and road damage at $270 million; and another $250 in damage to health, welfare, and unemployment payments. The explosion left more than 370,000 people temporarily out of work. Heavy losses were also suffered in the fish industry of Portland and Vancouver. River ports there lost more than $5 million a day because of debris. More than 30 ships were still trapped upriver from those areas on June 30 and it eventually cost more than $44 million for the U.S. Army Corps of Engineers to reopen the rivers. There were additional economic losses from loss of tourism and for a cancelled industrial plant that would have employed 2,000 local workers.

Meteorological studies of the upper atmosphere and downwind and global effects of the ash cloud continued for several weeks after the eruption. Geological monitoring of the mountain has continued.

Summary of Scientific Factors: The need for scientific and technical information was high in this case. Prior to the May 18 eruption, FEMA had very little involvement in monitoring the geological activities at Mt. St. Helens. That had been the primary responsibility of the United States Geological Survey (USGS) and the United States Forest Service (USFS). Although the USGS and the USFS staffs had indicated publicly the potential extent of damage of a major eruption, the May 18 eruption was much more severe than scientists had considered likely.

Following the major eruption and the presidential declaration on May 21, President Carter selected Dr. Denis Praeger from the Office of U.S. Technology Policy to identify scientific needs and personnel related to the eruption, its aftermath, and recovery. Dr. Praeger, in turn, appointed Dr. Robert Wesson from the USGS's main office in Virginia to initiate a program of technology information dissemination. Dr. James Kerr (now Director of Research for FEMA) was the permanent Director.

With the assistance of FEMA staff in Region X, Dr. Wesson set up the Mt. St. Helens Technical Information Network in Vancouver to answer scientific questions and provide information related to the eruption. During a six-week period following the explosion, 33 technical bulletins were issued. These covered a variety of subjects, including how to deal with the volcanic ash when operating cars or machinery, effects of the ash on human health, agriculture, and furniture; and other unusual problems. This system operated smoothly in providing information.

William Brown, community planner for natural hazards in FEMA Region X and a key member of the Mt. St. Helens Technical Information Service, said that the volcanic eruptions, lava flows, floods and avalanches posed a life-threatening situation on the mountain. In order to protect human lives, federal and local government officials closed the mountain down to non-government personnel, including scientists and journalists. However, the explosion had brought scientists, both physical and social, to the area from all over the country who wanted to study both the physical and social aspects of the event. Brown said it was difficult to negotiate whom to allow on the mountain. In addition, Brown said it was difficult to make sure that the volume of scientific studies being done did not destroy the subjects of the studies. For example, a piece of physical evidence handled too many times became worthless or a resident asked too many questions by scientists and journalists became jaded and uncooperative. Brown said that the FEMA office, in cooperation with the USGS in Vancouver, had developed better procedures since the 1980 eruption for distribution of information and quality control on scientific studies during such events.

CASE HISTORY NO. 5 - KANSAS CITY HEAT WAVE, 1980

The summer of 1980 was brutally hot across the midsection of the United States, and resulted in 1,265 heat-related deaths. Missouri had the largest number of such deaths, 311, including 148 in Kansas City. The state of Kansas had another 72. Although this heat wave affected most of the Midwest, and extended into Texas, the focus herein is on its effects in Kansas City.

The Heat Wave of 1980 began in Kansas City in mid-June when the temperature failed to drop below 85°F for several consecutive days. By July 16, there had been 139 heat related deaths in Kansas City - including 23 on July 11 alone. Later studies showed the majority of victims (72 percent of those in Kansas City) were over 65, lived in the inner city in older, usually non-air-conditioned housing, and were at the lower income levels.

The heat also caused significant agricultural damage, including damage to 50 to 60 percent of Missouri's pasture land and 40 percent loss of the anticipated hay crop. Sixty counties in Missouri qualified for the federal livestock feed relief program.

Dr. Virginia Gill, assistant director of the Health Department of Kansas City and coordinator of the city's response to the heat, said that city officials became concerned over constantly rising temperatures in early July. She called together representatives of various city departments, including police and fire department officials, along with representatives of private social agencies, such as the Red Cross and Salvation Army, in order to orchestrate a unified response to the crisis. The group was called the Heat Wave Task Force.

The City's Health Department began its efforts with publication and distribution of a one-page information sheet for tips on how to deal with the heat. This included suggestions such as cutting down on physical activity and alcohol consumption, wearing light weight clothing, and drinking plenty of fluids.

Several churches and social agencies set up air-conditioned comfort shelters throughout the city--particularly in inner city areas where the majority of citizens lived in older, non-air-conditioned, multifamily dwellings. The Kansas City Police Department made an extra effort to watch the homes of those using the shelters because many citizens feared robbery and vandalism while leaving their homes unattended for long periods of time. Community agencies worked to identify elderly citizens who might be particularly susceptible to the ill effects of the heat. Neighborhood block watch efforts were planned to check on citizens and to guard homes of those using the shelters.

As the heat continued, city officials realized that less than 100 persons were using the 30 shelters--at least partially due to fear of or inability to leave their homes. Officials then began efforts to make the homes of those high-risk residents more comfortable by providing cooling equipment. A city-wide drive for donations of fans and/or air-conditioning units was launched. Kansas Citians responded generously by donating numerous fans, leaving them at fire stations throughout the city. The fans were distributed--primarily to elderly, lower income inner city residents identified by social agencies. Later, officials found many people were either unable or unwilling to use the fans for fear of high utility bills.

Dr. Gill set up a command post at the city police department shortly after July 1 in order to centralize heat relief operations. Numerous phone lines, extra police services, and help from the Red Cross and Salvation Army enabled city officials to respond relatively well to the crisis, Dr. Gill said. Local media were very helpful in distributing health and safety information. Dr. Gill said that no additional scientific information or assistance was needed from either state or federal officials.

FEMA staff met with representatives of the city government, the Red Cross, Salvation Army, and Office of Aging during the crisis. Francis X. Tobin, then director of FEMA Region VII, reported city officials were handling the situation competently and did not request federal assistance.

However, Missouri Governor Joseph Teasdale did request a federal disaster declaration for the entire state of Missouri on July 14. In his memo addressing the request, Mr. Tobin reported that the National Guard had been activated in St. Louis, and that additional cooling equipment had been delivered there. Kansas City's fan donation and distribution system was meeting the demand, Mr. Tobin reported. Mr. Tobin recommended against declaration of a major disaster, and the petition was denied. Subsequently, as the heat wave continued, Governor Teasdale repeated his request for a federal disaster declaration and this time Mr. Tobin supported it. However, the request was again denied in Washington.

Eventually, Missouri and Kansas did receive federal assistance through the Community Services Administration. Almost $2 million were received to pay higher-than-normal utility bills for low-income citizens. In addition, FEMA authorized the Center for Disease Control in Atlanta to assist local governments to identify more accurately high-risk groups and ways to reduce heat stress and death. The study later showed those at higher risk from continued heat were people who did not leave their homes often, usually elderly, ill people or infants.

In the months following the heat wave, Kansas City health department officials prepared a multi-phased response plan should such a crisis recur. This included a public education and planning phase; an alert and monitoring phase as temperatures rose; and finally a full operation phase if an emergency was declared.

Summary of Scientific Factors: This case represents a good example of a well-managed local crisis. City health department officials report that although they did not know how to anticipate fully the health toll of the extended heat wave, they were able to respond appropriately to the city's needs. Local officials were able to meet immediate crisis needs and Center for Disease Control representatives provided a study of long-term effects. Neither federal assistance nor outside scientific guidance was needed. Local science and technology needs involved weather prediction and medical science related to the effects of heat stress on human health.

CASE HISTORY NO. 6 - LEGIONNAIRE'S DISEASE, 1976

The Pennsylvania department of the American Legion held its annual convention at the Bellevue-Stratford Hotel in Philadelphia from July 21 to 24, 1976. More than 4,400 delegates attended, many accompanied by their spouses. Beginning on July 23, many of the attendees developed a serious and puzzling illness that became known as Legionnaire's disease. Many victims did not become ill immediately, but did so after they returned home. In addition to the conventioneers, several others who had been in the Bellevue-Stratford Hotel also became ill. Eventually, 182 cases were reported, of whom 29 died and 147 were hospitalized. Most of these deaths (26) occurred between July 27 and August 16, 1976. The outbreak was never classified as a federal disaster, but it caused near panic for a time.

The state Commandant of the American Legion called Philadelphia health officials on August 2nd, stating that he had received reports of several legionnaires dying from a type of pneumonia shortly after the convention. City health officials soon discovered the epidemic nature of the disease and requested help from the Center for Disease Control in Atlanta (CDC). The CDC sent 23 epidemiologists to collaborate with state and local officials in trying to discover the cause of the disease and find a treatment.

The illness seemed to appear within two days of exposure at the convention. The symptoms included a general malaise, muscle ache, headache, diarrhea, coughing, chest and abdominal pain, and a fever of escalating intensity. The fever often rose as high as 102° to 105°F, leaving some of its victims stuporous. Older conventioneers appeared to be more affected and/or affected at a higher rate than younger ones. The majority of the victims were men. Most of those were people staying at the hotel or attending the convention. They seemed to suffer the disease at a higher rate than those who were in the hotel for shorter periods. The disease did not appear to be spread from person to person, but appeared most likely to be caused by a bacteria or virus that was airborne at the convention site.

More than 90 percent of those with the disease appeared to suffer from pneumonia and required hospitalization. Without treatment, 20 percent died of progressive pneumonia. Eighty percent recovered gradually, some with prolonged weakness or lung damage. Legionnaire's Disease was, however, different from other pneumonias because its victims suffered confusion, diarrhea, and red blood cells in the urine, but not a runny nose or sore throat. The usual pneumonia-causing bacteriums were absent in the sputum and patients also failed to respond well to standard antibiotics. By now the news media were filled with contradictory stories about this strange new illness, which some authorities were attributing to a deadly new virus, and others to toxic chemicals (such as chlorofluorocarbons from the air conditioning system, or a volatile metallic compound such as nickel carbonyl, feloniously added to the air).

State health officials notified the Pennsylvania Medical Society, the Pennsylvania Osteopathic Association, and the Hospital Association of Pennsylvania of a potential statewide epidemic, possibly of a threatening new disease. They requested reporting of potential cases and the state health department became the center for planning and data collection. Public health nurses searched hospitals in their districts for potential cases and a direct telephone line was set up in Philadelphia for the public to report potential cases.

CDC, state and local health department officials made eight epidemiologic surveys to try to understand the strange disease and its outbreak. Those surveyed included the legion conventioneers, delegates, hotel guests, hotel employees, roommates of patients, and Philadelphia hospital emergency room and admissions staff. Records from previous pneumonia and influenza cases in Philadelphia were reviewed. Epidemiologists from CDC studied autopsy results, tissue cultures, and interviewed patients who survived the disease. One by one they ruled out the several chemicals that had been proposed as the cause. They concluded that all the deaths related to the disease were due to "interstitial pneumonia" and complications associated with viral rather than bacterial pneumonia. The virus, however, was unknown. State health officials said that the investigation could take as long as 2 years.

The organism responsible for the Legionnaire's disease was eventually identified later that year by a CDC microbiologist as a common bacteria, one not previously associated with pneumonia, but one that responds to the antibiotic, erythromycin. The bacteria is widespread, lives in the soil and can become airborne if the soil is disturbed. If the bacteria is sucked into an air conditioning system, it thrives in the moist environment. The bacteria can easily be blown throughout a building in the cooled air. This was apparently the case in the Bellevue-Stratford in Philadelphia.

Health officials considered it likely that the bacterium had been simply unrecognized in earlier cases. For example, a disease called Pontiac Fever had appeared in 95 of 100 people working in the County Health Department in Pontiac, Michigan a few years earlier. Their symptoms were similar to those suffering from Legionnaire's disease, but all of those people recovered from the illness. Retesting of specimens from those patients then showed the presence of the same bacterium as those of the Legionnaires.

Summary of Scientific Factors: The fear of an incipient epidemic of puzzling Legionnaire's Disease prompted Philadelphia and Pennsylvania health officials to call in epidemiologists, microbiologists, and infectious disease specialists from CDC immediately. The severity of the illness, the failure of standard medical treatment, and the rapid deaths of so many victims demanded immediate services of the country's most sophisticated health specialists. One of the local health officials in charge, Dr. Robert Shirrar, said that he felt confident CDC provided the best possible technical assistance. Clearly, however, additional scientific and technical information was needed immediately in this case, but it could not be provided without additional research. Since it was not declared a federal disaster, FEMA officials had no direct role--only support when asked.

CASE HISTORY NO. 7 - MEDFLY CONTROL CONTROVERSY, 1981

In July 1981 Governor Edmund G. (Jerry) Brown, Jr., asked President Reagan and the Federal Emergency Management Agency to declare three counties at the southern end of San Francisco Bay to be disaster areas because of an outbreak of the Mediterranean fruit fly (Medfly). The Federal Government declined to do that, but eventually provided about one-third of the nearly $100 million effort that was required to eradicate this dire threat.

The Medfly is one of the world's most destructive agricultural pests. The female fly deposits its eggs in the skin of the growing fruits of nearly 250 susceptible herbs, vines, bushes, and trees of garden, arbor, and orchard; the larvae that hatch burrow into and rot the fruit and cause premature drop. Of West African origin, the Medfly spread over the past century to southern Europe, the Near East, South America, Central America, Mexico, and Hawaii. Constant vigilance has kept the Medfly from becoming established in the continental United States. Incipient infestations in Florida, Texas, and the Los Angeles area between 1955 and 1974 were attacked vigorously with pesticides and other control measures and were eliminated. Monitoring programs exist in most such areas to detect the appearance of new Medflies.

In mid-1980 Medflies were discovered in "the Silicon Valley," suburban areas near San Francisco Bay, presumably brought back by a returning tourist from Hawaii or Latin America. The California Department of Food and Agriculture under Governor Edmund G. (Jerry) Brown, Jr. and in consultation with the U.S. Department of Agriculture, established a pest control program that involved searching for infested locations, removal of contaminated fruits, pesticide treatment around infested trees, and warnings to citizens not to carry any fruit out of designated areas. Entomologists apparently did not believe the Medfly could survive the cool wintertime temperatures in this part of California, and the Medfly program was a fairly low-level effort until the end of 1980 when concern began to increase. Governor Brown directed an intensification of the program. Over a thousand paid and volunteer workers would visit some 300,000 residences in a 50 sq mi area, and a 530 sq mi quarantine zone with check points would be established. Millions of irradiation-sterilized Medflies (laboratory reared) would be released around infested areas to suppress the reproductive capacities of the wild Medflies. Governor Brown resisted recommendations to use an aerially-dispersed bait formulation of malathion; the idea of being sprayed with chemical pesticides might be very unpopular with suburbanites, many of whom feared adverse health effects.

By July 1981 Medflies had been found in several new areas. Even more serious was the suspicion that the sterile fly program had mistakenly released 50,000 or more fertile Medflies. The Medfly problem appeared to be getting beyond control, threatening California's $6 billion/year susceptible fruit and vegetable industry. Governor Brown still resisted adoption of an aerial pesticide application, implying that it posed unacceptable health risks. In response to concern from agribusiness interests in other fruit-producing states and from an international trading partner, Japan, the USDA then threatened to quarantine all susceptible California produce unless an aerial pesticide application program was initiated at once. The Governor protested strongly, but acquiesced.

A massive aerial pesticide application program was initiated in mid-July over considerable public resentment and fear.* Even so, the success of the program was in grave doubt for the next 2 months, as new infestations were reported repeatedly. Of further concern were the demands by other states and countries that all California produce be fumigated to prevent spread of the pest. Not only did too few fumigation facilities exist, but the fumigant of choice was a known carcinogen; the adequacy of measures and standards for protection of workers and consumers from exposure was questioned by some people. Shortly after the spraying began, White House officials revealed that FEMA was reviewing a request from Governor Brown to declare three counties a disaster area; it was not granted. When the Medfly appeared in the agriculturally rich San Joachin Valley, near-panic engulfed agricultural interests and state officials.

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* The Red Cross set up 4,000 cots in shelters outside the initial spray areas for persons who sought refuge. Staging areas for spray helicopters and supplies were kept secret to avoid protestors; shots were fired at some helicopters.

The area sprayed at least once eventually reached over 1,100 sq mi (some 340 sq mi were sprayed up to 12 times) and the quarantine zone reached 3,900 sq mi before the Medfly was brought under control.

Essentially none of the widely feared health or environmental effects of the aerial pesticide application program were ever observed. Governor Brown's failure to adopt it sooner caused a severe decrease in his political stature - many analysts attributed the public's perception of his response to the Medfly threat as a major cause of his defeat in the 1982 election for a U.S. Senate seat.

Summary of Scientific Factors: The Medfly case demonstrates that it is of little value to have scientific information available if it is not properly used. Governor Brown's early decisions reflected the fears of the residents of the affluent "Silicon Valley" over the alleged health and environmental effects of being "sprayed with chemical poisons." In fact, however, the technology had advanced to the point that human and environmental exposure was minimal; an insecticide of only moderate inherent toxicity was diluted in granular bait which contained a sex attractant to bring the Medflies to it after it fell to the ground. People were not going to be subjected to a toxic fog as many imagined.*

Successful response to the Medfly threat required a wide range of scientific, technical, and management skills. These included entomology, toxicology, public health, environmental impact analysis, economic analysis, and several kinds of pest control expertise, such as chemical pesticide usage, production of irradiation-sterilized medflies, aerial application techniques, and fumigation of produce. In addition, the input of behavioral scientists may have been helpful, if it had been used. Communications with the public was critical for acceptance, but was not handled very well at the local, state, or national level.

CASE HISTORY NO. 8 - THE GREAT NORTHEAST POWER FAILURE, 1965

On November 9, 1965, an electrical power failure developed in the Northeastern United States and Southeastern Canada just as millions of people were headed home from work at dark. Within minutes some 25 to 30 million people in parts of eight states (including much of New York, New Jersey, Pennsylvania, Vermont, New Hampshire, Massachusetts, Connecticut, and Rhode Island) and two Canadian provinces (Ontario and Quebec) were without electric lights or power. An 80,000 square mile area was affected, as the massive blackout engulfed most of the affected areas for 5 to 15 hours until electrical service could be restored. The episode was not a Federally declared disaster, but it provides many lessons related to emergency causes and responses.

* It is ironic that the residents of Silicon Valley, the heart of America's modern electronics and communications industry, should have been so misinformed.

Subsequent investigations were to find that the cause of the blackout was in the power grid system that connected producers and users and in ostensibly safety-insuring features that had been incorporated into the system. Since the 1920s and especially during World War II the approximately 3,600 power systems became increasingly interlinked so that they could trade or import power at times when local demand exceeded generation capacity. By 1965, 97 percent of them were linked into five major grids, of which the blacked-out area was one. The blackout was initiated when a transmission line in Canada that was carrying a near capacity load unexpectedly tripped a telephone-sized circuit breaker--a safety device. The load was automatically switched to four other lines, but these were already at capacity also and their circuit breakers tripped. The result was that 1.7 million kilowatts of electricity was suddenly switched from Canadian lines to United States lines and activated a chain reaction of safety breakers and relays throughout the grid. Entire power plants were automatically shut down and many hours were required to reestablish the complex system.

The outage began along the Niagara frontier in Upper New York State. Ontario Hydroelectric Company workers in the Richview Control Center noticed a surge of electricity into the grid in the wrong direction. They attempted to switch the system and isolate the power problem, but it spread throughout the interlocking power network. Toronto, Canada lost its power at 5:16 PM. In the United States; the blackout started in Niagara, New York, at 5:17 PM, and had moved to Syracuse by 5:22 PM, and to New York City by 5:27 PM. Operators of some of the individual stations tried to cut from the grid to guard against an overload. The giant Consolidated Edison Company was receiving electricity from the Niagara Mohawk Station when it noticed the flow was reversing. Con Ed officials telephoned Niagara officials to warn them that they were cutting away from the grid system, but it was too late. The New York system shut down as the city's nine generating stations were cut off by automatic protective devices. Con Ed reported later that three units were damaged, however, by the surge of electricity. The only parts of the city of New York that were not blacked out were Staten Island and some sections of Brooklyn, areas served by separate generating stations.

Emergency generators were started wherever available. Of particular value were those at broadcasting stations and telephone companies that enabled the public to get information on the nature and scope of the blackout. Within 10 minutes of the outage, some radio stations were able to relay essential news through car and transistor radios. That may have prevented a panic. Power returned gradually. Outlying areas received their power back relatively quickly. Buffalo had its power back in 40 minutes; Rochester in 4 hours; Boston in 5 hours; New Hampshire within 3-1/2 hours; and Toronto by about 8:30 PM. Power returned to Coney Island, the same evening by 8:42 PM, to Brooklyn at 2:00 AM on November 10, to Queens by 4:20 AM; and to Westchester County and the Bronx by about 7 AM.

New York City was hit especially hard. Some 800,000 people were stuck in subways and elevators, most surface and air transportation was halted or badly jammed, and almost all normal activities were disrupted.

The airports closed and more than 200 planes had to be diverted. Rail traffic stopped and two editions of the city's newspapers were cancelled. Nearly 10,000 persons were stranded in New York subways for up to several hours, many until midnight. Sixty persons were forced to remain 14 hours below the 60th Street Tunnel. More than 1,700 persons were stranded on four trains on the Williamburg Bridge and were assisted out one-by-one along a narrow catway. This rescue operation took 5 hours. Most persons in elevators were rescued relatively quickly, although some remained trapped as long as 7 hours. Seventy-five persons were rescued by crews who were forced to break through the walls.

More than 5,000 National Guardsmen were called in. National Guard armories were opened as shelters for persons who were unable to get home for the evening. More than 5,000 off-duty police and 7,000 firemen helped to keep the city moving.

The crime rate during the blackout was lower than normal, although there was an increase in the number of car accidents, fires, false alarms, and broken store windows. There was no major incident of vandalism. The only major incident was a 2-hour riot at the state prison in Walpole, Massachusetts.

Summary of Scientific Information Factors: Much scientific and technological expertise was required in the hours immediately after the blackout. Most critical were those skills needed to provide emergency power and light, to assist in rescuing trapped people, and to explain the incident sufficiently to the population to avoid panic.

The blackout caused a sensation with the public and in the media: they demanded to know why it had happened, and to have reassurances that it would not be repeated. President Lyndon B. Johnson and two Congressional committees called on the Federal Power Commission and the electric utilities (especially the Consolidated Edison Company) for an explanation. The incident, amplified by closely following blackouts in the Southwest and in England, generated a great controversy over the desirability of the grids, and spurred intensive efforts to improve their reliability. The post-blackout analysis required primarily the intensive participation of persons already intimately knowledgeable with the complex technologies of power generation and transmission, and particularly those of switching and safety devices for high voltage, high current lines.

CASE HISTORY NO. 9 - THE NEW YORK CITY BLACKOUT, 1977

A massive power failure occurred in the five boroughs of New York City and suburban Westchester County on July 13 and 14, 1977. This blackout left more than 9 million people stranded without electricity for 4-1/2 to 25 hours.

This blackout was touched off by a lightning storm which hit two Consolidated Edison 349,000 volt transmission lines. This automatically shut down the two largest generating facilities. The first bolt hit at 8:30 PM July 13 in Buchanan, New York, 12 miles north of New York City. The station's transformer was hit, cutting off power at the Indian Point No. 3 Nuclear Power Plant. The second lightning strike set off a series of overloads and short circuits, cutting power from the Ravenswood No. 3 plant in Astoria, Queens. At 8:34 PM the entire city of New York went black.

LaGuardia and Kennedy International Airports were closed for 8 hours. Highways and city streets lost their traffic lights, and the two tunnels connecting Manhattan to Queens and Brooklyn were closed for lack of ventilation. The blackout also closed stores, banks, state offices, and the New York's American Stock Exchanges on July 14.

More than 4,000 persons were evacuated from seven subway trains, many of which were stopped between stations. All commuter rail service was stopped. Many hospitals, including Bellevue, the city's largest hospital, were without power during the blackout. Doctors and other staff were forced to use hand-operated respirators to enable critically ill patients to breathe. There were also water shortages as the city pumps stopped. This was a difficult loss since the temperature on the day of the blackout was in the mid-90's.

In marked contrast to the 1965 blackout, a great deal of looting and vandalism occurred during the 1977 blackout. More than 3,700 persons were arrested. The worst vandalism occurred in the Black and Hispanic neighborhoods of Brooklyn, Harlem, and the South Bronx. More than 100 policemen were injured. There were 500 fires, of which 55 were severe.

<u>Summary of Scientific Information Factors</u>: Consolidated Edison officials referred to the blackout as a natural disaster, but Mayor Abraham Beame charged Consolidated Edison with gross negligence. He said the company had ignored the scientific and technical safeguards recommended after the 1965 blackout.

The scientific and technical skill needed immediately after the blackout were very similar to those needed in the 1965 episode, and were provided by individuals, companies, and local agencies. One of FEMA's predecessors, the Federal Disaster Assistance Administration, had only a three person staff in the New York office in 1977. Norman Steinlauf, one of those three and currently deputy regional director in Region II in New York, said that his agency only monitored the situation and was on call to local and state government officials should the situation worsen and/or be declared a disaster. Consolidated Edison staff directed the technical activities to restore power, and local law enforcement officials worked to rescue those stranded and keep the situation calm. The federal government provided little direct emergency management or technical expertise.

CASE HISTORY NO. 10 - THE LOVE CANAL DISASTER, 1978 TO 1979

Between 1947 and 1952, the Love Canal area near Niagara Falls, New York, was used as a dumping group for toxic wastes by the Hooker Chemical and Plastics Corporation, and apparently others. In 1953, Hooker sold the area to the Niagara Falls Board of Education for $1. The area was graded over, a school and houses were built, and the houses sold to the public.

After several years, the chemicals began to surface. In 1976 they were found on school playgrounds, yards, and in home basements. Tests by state health officials showed more than 80 different chemical compounds, at least seven of which were suspected carcenogens.

The evacuation of a small area inside Niagara Falls began August 4, 1978. Those asked to leave the area were provided money for rent and moving expenses by New York State and the Gannett Company, the parent comany of the Niagara Gazette.

On August 7, 1978, the New York State Health Commissioners issued a warning, stating that the area represented "grave and imminent danger." The Commissioner of Health, Robert P. Whalen, recommended that pregnant women and children under the age of two leave the area immediately because of the higher than average rates of birth defects and miscarriages within the populations. President Carter then officially declared the Love Canal area a disaster area, due to the wide contamination from long-buried chemicals.

By August 7, Hooker Chemical had offered to help pay for emergency evacuation drainage pumps to rid the area of chemicals (Hooker disclaimed damages since it said the nature of the dump site had not been kept a secret). City and county officials also offered to help pay for the drainage of the chemicals. On the same day, the New York state and federal governments publicly announced that they would split the cost of cleaning up the area. The federal government now also provided funds to people who were forced to move following the presidential disaster declaration. At this time, 239 families were evacuated.

On May 16, 1979, the results of a federal study were made public. The study showed that 30 percent of the residents of the Love Canal area suffered chromosomal damage.* Eleven of the 36 persons tested on January 18 and 19, 1979, showed rare chromosomal changes occasionally associated with cancer. At a Washington, D.C., news conference on May 17, EPA's Dr. Stephen Gage stressed that there was not necessarily a cause or relationship between the chromosomal abnormalities and cancer, but he said that the blood tests showed that the residents of the area had suffered exposure to harmful chemicals. The deputy administrator of the Environmental Protection Agency called the Love Canal area one of the worst chemical problems in modern history.

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* This study was made by the Federal Government in support of its suit for $124.5 million against Hooker Chemical to pay cleanup costs.

On May 21, 1979, President Carter declared a state of emergency in the Love Canal area. By May 27, EPA officials reported that a second study had shown that residents of the area had also suffered peripheral nerve damage. These events resulted in the evacuation of an additional 710 families. Under the presidential order, the federal government would pay for evacuation and temporary housing.

Efforts to resolve the problems at Love Canal have continued since 1979, generating an almost soap opera like series of news articles. Recent news reports have claimed that NIH studies of former Love Canal residents have failed to confirm the dire health effects indicated by EPA, which had been the reason for the massive relocation program. Further studies will be necessary to resolve this matter. Nevertheless, the term "Love Canal" has become a synonym for modern technological hazards.

Summary of Scientific Factors: The need for scientific information of a highly specific nature and of a reliable quality was very high in this case but has been poorly met. In the initial evacuation in 1978, a FEMA predecessor agency was sent in to coordinate federal financial and technical assistance. Norman Steinlauf, the federal coordinating officer, said that the health and safety issues had been decided by New York state health department officials in conjunction with local staff and representatives of EPA and CDC already called to the scene. He said his role was to oversee the evacuation of specific "inner circle" homes near the contamination site and the relocation of families involved. Steinlauf said that the staff had no specific needs; they simply managed the logistics of the evacuation operation. The analytical chemistry, toxicology and epidemiology studies were conducted by other federal and state agencies.

In the second evacuation, FEMA staff served a similar role. This time they orchestrated distribution of federal assistance authorized by the federal legislation.

CASE HISTORY NO. 11 - REACTOR FAILURE AT THREE MILE ISLAND, 1979

A series of breakdowns in the cooling system of Reactor No. 2 at the Three Mile Island Nuclear Power Plant led to a release of radiation into the air in the early morning hours of Wednesday, March 28, 1979. The facility, owned by Metropolitan Edison Company and two other utilities, is located in the populous Susquehanna River Valley 10 miles south of Harrisburg, Pennsylvania and about 90 miles from Philadelphia.

Utility officials initially indicated that the release was a minor problem that would soon be resolved, but it signaled the start of a 10 day scare that eventually involved talk of a possible core meltdown, a possible explosion from a hydrogen gas bubble that had formed in the overheated reactor, and a possible need to evacuate tens of thousands of people. Media interest was intense, and the public, locally and nationally, received frequently contradictory or garbled accounts from different authorities on the scene, or from different reporters about what was happening and what could be expected.

The exact sequence of events leading to the release of the radiation was strongly debated by Metropolitan Edison, the Nuclear Regulatory Commission, the state of Pennsylvania, and the companies who had built elements of the reactor. Fully satisfactory explanations did not develop until well after the crisis had ended. Met Ed officials did not notify state and county authorities of the accident until 7:30 AM, when they declared an emergency at the plant site. They said that the delay occurred because they had not been aware of the radiation leakage. According to Met Ed, the accident began when a valve failed in the cooling system pump. (Officials of Babcock and Wilcox, the firm which designed and built the reactor, said there were no valves inside the pump.) Met Ed officials said that the cooling water for the reactor was then interrupted. That stopped the steam turbine and consequently shut down the reactor. But the reactor continued to generate heat and that, in turn, stimulated the emergency cooling system. But, at some point before the switchover from the primary to the emergency cooling system, a plant operator had manually turned the emergency system off, and only later turned it back on. But, by then, uranium fuel rods in the core had overheated and were damaged, making withdrawal difficult, and leading to serious overheating. The water used to cool the core spilled onto the reactor floor, turned to steam and had to be vented to the atmosphere to relieve pressure. Inside the core the hot steam reacted with the metal cladding on the rods to release hydrogen gas, which began to build up.

During the subsequent investigation, Nuclear Regulatory Commission investigators blamed Metropolitan Edison for allowing three auxiliary cooling pumps to remain closed for two weeks before the accident. This represented a major violation of NRC policy since it was the agency's policy that two sets of pumps must be operating at all times. The NRC also claimed that the Met Ed plant operators misread pressure level indicators and prematurely turned off the emergency cooling system. They blamed a series of human, mechanical, and decision errors.

At first plant officials thought the radioactive steam was the only source of radiation outside the plant, but NRC officials later reported that the radiation from the damaged core had penetrated four-foot thick walls. The radiation leaks continued into the following day with low levels of radioactive iodine measured as far as 20 miles away. The leakage was expected to continue slowly for 24 hours to a week.

Suddenly, however, a new burst of radiation escaped into the air March 30, and Governor Thornburgh now ordered the evacuation of pregnant women and preschool children within a five mile radius of TMI. About 5 percent of the 20,000 persons living within a mile of the plant apparently left the area voluntarily at some point during the crisis. Civil defense authorities said that at least 1,200 persons had gone to emergency shelters. Approximately 80,000 persons living near the plant went away over the weekend following the accident. Following the March 30 release, technical engineers worked feverishly to cool down the overheated fuel core and to reduce the bubble. Evacuation plans were prepared for the residents of cities located 10 and 20 miles downwind of the plant.

On April 1 President Carter visited the reactor site and declared the radiation surrounding the plant to be at a safe level. The next day officials of the Nuclear Regulatory Commission and Metropolitan Edison announced a dramatic reduction in the size of the bubble and significant cooling of the core. By April 3, one week after the original incident, the bubble had been eliminated.

Power plant officials continued their efforts to take the reactor to a "cold shutdown." The NRC installed its own dosimeters to measure the accumulated radiation on April 9 and the crisis stage was declared officially over. Three Mile Island Reactor No. 2 was finally shut down April 27, 1980, and has remained out of service for over three years. An adjacent reactor also shut down, because of public concern, for safety checks.

Governor Thornburgh rescinded his advisory for women and children on April 9 and allowed them to return to the area. He said there was no threat to public health from milk or drinking water. U.S. officials had said that small amounts of radioactive iodine were detected in local milk samples from nearby farms as early as April 3. The NRC official spokesman, Harold Denton, noted that the highest iodine level found off-site was 31 picocuries per liter, and in most cases was only 10 to 20 picocuries per liter. He said it was not until levels reached 12,000 picocuries per liter that it was considered dangerous. He said that the cumulative radiation dose for local residents was less than 100 millirems and was not hazardous. Officials of the U.S. Department of Health, Education, and Welfare announced in mid-April long-term health studies among pregnant women, workers, and children in the area to determine any effects of the low-level radiation from the plant.

The TMI incident sparked worldwide protest and concern over the safety of nuclear power. It followed closely the release of the movie, "The China Syndrome," which dramatized potential disaster of a core meltdown in a nuclear power plant. On April 10, the NRC had said that it would allow eight other Babcock-Wilcox plants to continue to operate, and it refused to close the Rancho-Seco plant near Sacramento, California, despite the request of Governor Jerry Brown. President Carter also announced the establishment of an independent commission to investigate the TMI incident.

The incident severely damaged the near-term future of nuclear power in this country. The Nuclear Regulatory Commission had already shutdown five northeast atomic power plants because of design failure. The Nuclear Regulatory Commission now tended to disagree with its own 1975 "Rasmussen Report," which had claimed that the chance of a nuclear power plant accident was no greater than the chance of a major city being hit by a meteor. At the time of the accident, there were 72 nuclear power plants operating in this country providing 13 percent of the nation's electric power. In some areas these plants were providing as much as 50 percent of the power. An additional 125 plants were also under planning or construction, but their future was covered by a dark shadow as a result of the incident at TMI.

Summary of Scientific Factors: The need for highly specific and highly reliable scientific and technical information was extremely large at TMI. This was the first major accident at an operating nuclear power plant in the United States. It highlighted the potential dangers of malfunctions in both mechanical and human systems in the operation of nuclear power plants. By April 10, the day after the crisis was officially ended, officials of the NRC said that all rules and regulations pertaining to nuclear power plants would be reviewed after further study. The agency staff said that all 43 pressurized water reactors operating in the United States were suspect of being susceptible to similar mishaps. At the same time, the federal government's Advisory Committee on Reactor Safety recommended that NRC require new standards for monitoring and safety.

Transcripts of the NRC closed meetings during the crisis were released by mid-April following a Congressional subpoena. The tapes indicated that the Commissioners and the NRC technical staff were concerned about the inadequacy of information from the plant site during the crisis. NRC Chairman Joseph M. Hendrie has stated that both he and Governor Thornburgh did not have sufficient information to make intelligent decisions concerning the likelihood of meltdown or explosion from the hydrogen gas bubble and the subsequent need for evacuation. The tapes also revealed that the leading NRC official at the plant site, Harold Denton, had genuine concerns about the technical capabilities of the Metropolitan Edison engineers to resolve the crisis.

Although the Three Mile Island accident was not a declared federal disaster, FEMA officials were called to the White House the day after the radioactive emission. Robert Adamcik, now regional deputy director of FEMA in Region III, said he and several other FEMA staff met with representatives of the Department of Energy, the Environmental Protection Agency, and NRC staff. He said that during the meeting, he was designated as the coordinator of all federal agency activities off site from the plant. Mr. Denton was designated as the head of technical federal officials at the power plant. Representatives of the Defense Civil Preparedness Agency were also assigned to the area to prepare evacuation plans.

The lack of experience in managing this type of accident, the potential for destruction, and the possibly long-term after-affects made information management during the crisis extremely difficult, according to Mr. Adamcik. He said it was very difficult to translate for the lay public what the technical staff working with Mr. Denton at the plant were saying. Mr. Adamcik said he worked with representatives of the Pennsylvania Health Department to understand the potential effects of radiation already leaked or that would result from a meltdown. He said they were concerned about what kind of and how much medication would be needed to counter some of the potential affects of radiation exposure and radioactive fallout.

Adamcik recommends that in a future similar case a field office should be established for liaison between the NRC, other federal officials, utility engineers, health experts, and other state and local government officials. Such a liaison should also provide press information from one central location.

The public suffered from confusing misinformation, during Three Mile Island, Adamcik said. More than 600 reporters had flooded into the plant area. They often chased engineers--and not necessarily the ones in charge--from building to building looking for the latest information. Information obtained was not always properly verified, and misleading information was often printed or released. The status of the events changed hourly, Adamcik said, and often technical staff working on one aspect of the crisis did not know what was happening elsewhere. Eventually, reporters were told that Denton was the only official spokesman for technical information from the site, and that Governor Thornburgh was responsible for all other information.

Adamcik said that he was certain that the best possible federal staff were on site during the crisis. He said they did not lack any scientific or technical staff that might have been useful. One must note, however, that much more scientific and technical information was needed much sooner, and that which became available as the incident developed was poorly organized in its transmission to the public. These communication problems changed significantly the views of much of the American public on the safety of nuclear power plants.

CASE HISTORY NO. 12 - WARTIME SCENARIOS

The term "wartime" covers a very broad range of situations, including quite limited conflict with a smaller nation at one end to a nuclear exchange with a superpower at the other. The military aspects of the full range of situations have been the subject of an enormous amount of study and planning since World War II, while the civil defense measures that would be needed in event of a nuclear weapons exchange has been intensely studied for over 25 years.

The scientific guidance needed by civil defense emergency response organizations will vary greatly depending on the nature of the enemy (military capability, vulnerability, strategies, etc.) and the locus of conflict.[20-22] In the present brief study, the scientific and technological aspects of response to two levels of wartime problems are examined: the first involves response to organized terrorism, sabotage and vandalism, and the second involves response to the threat of nuclear attack.

1. Response to Organized Terrorism, Sabotage and Vandalism: A conflict with nations which do not have a capability to deliver major strikes at U.S. territory, may still cause serious civil defense problems. This is especially true for those nations for which a substantial sympathetic feeling may exist among U.S. residents (e.g., certain Moslem, Asian, or Latin American nations). The greatest need may be a response to terrorist or sabotage activities by groups of some of these individuals. Alternatively, an unpopular Vietnam-type conflict may generate a need to respond to acts of mass protests and vandalism by antiwar activists. Such emergency events would tend to be more regionally specific than would a confrontation with a major

power. Our discussion in this case study emphasizes the appraisal of scientific guidance to regional FEMA offices or other emergency response organizations in the event of organized, overt terrorism, since vandalism and protests will probably be handled primarily by local law enforcement measures.

The number and severity of terrorist incidents aimed at civilian populations have increased dramatically worldwide in the last 10 years. These acts are usually politically motivated and designed to engage the maximum amount of publicity. The participants are usually members of an organized group who claim credit for the act, which is designed to cause an effect beyond the immediate physical damage threatened. Terrorists are usually part of non-governmental groups, but governments are also capable of terrorist activities. In some cases, terrorist tactics by government officials are designed to repress internal dissent.

In the United States, the number of terrorist incidents has declined since 1977, when there were 111 acknowledged incidents; in 1981, there were only 42. The most active terrorists groups in the United States currently are Puerto Rican nationalists, anti-Castro Cubans, and Armenians, but this could change rapidly with changing world conditions. The United States has large numbers of alien residents and new immigrants from dozens of countries which are in some degree of turmoil, as well as a substantial number of other dissatisfied, distraught and mentally ill citizens.

Terrorism takes different forms in different parts of the world. But such activities are usually affected by a number of common factors including: mobility of world-wide travel, access to the media, vulnerability of a technological society; availability of weapons, perceived injustices, ethnic and religious divisions, failure of other avenues of dissent, a history of tradition of violence, and ineffective security forces. The increasing vulnerability of modern society to terrorist activities stems in large part from the complexity and interdependence of metropolitan, national, and international infrastructures such as systems for transportation, electricity, natural gas, water, communications, computers, and oil refineries or storage facilities. In addition, the growth of the number of operative nuclear power plants and military installations with nuclear explosives and biological and chemical weapons multiply that vulnerability. Furthermore, the terrorist act derives much power from the high value most societies place on human life and the new-found sense of national sovereignty that prevents strong military action or extradition by outside governments.

Terrorists usually operate with a limited repertoire of tactics; six tactics account for about 95 percent of acknowledged terrorist activities. These are: bombings, assassinations, armed assaults, kidnappings, barricade and hostage situations, and hijackings. Approximately one-third of all incidents involve hostages. The most common hostages are businessmen and diplomats. Some of the kidnappings take the form of a straight trade, e.g., imprisoned members of the group for the kidnap victims. Others are symbolic such as the kidnapping of General James Dozier, a NATO officer, whose seizure was claimed to demonstrate the weakness of the Western alliance.

The demographic profile of the terrorist usually shows the group member as a single, well-educated male, in his early 20s from a middle or upper class urban family. He is not usually psychotic and has no criminal association. He is frequently an absolutist, uncompromising, but willing and in some cases eager to take risks. The development of a terrorist can take a long time: the initial phase may be disenchantment with the establishment followed by alienation, boredom, and a new sense of purpose within the group. The terrorist can also become depressed and uncomfortable with the new role as an outlaw. The lack of successful accomplishment of the group's goals may lead to disillusionment and demoralization, but can also lead to increasingly brutal and criminal activities to support politically-motivated acts.

Some observers state that combating terrorism is a relatively low priority for national governments because the acts of terrorists make the government seem vulnerable, reactive, impotent, and incompetent except in the rare case of the dramatic rescue. This is not the attitude of U.S. law enforcement officials according to Charles Monroe, assistant director of the Criminal Investigations Division of the Federal Bureau of Investigation.[22] Federal government agencies have been increasingly effective in defusing terrorists groups. Monroe attributes this success to several factors such as: use of anticipatory tactics such as profiles; penetration of terrorist groups to improve intelligence gathering; more and better trained SWAT teams; and skilled hostage negotiators in 59 FBI field offices, supported by behavioral scientist, crisis managers, and psychoanalysts. The FBI's psycholinguists use written or oral communication to get information from the unknown extortionist, hostage-taker, or would-be assassin, e.g., an idea of age, sex, education, ethnic background, race, and proclivity to violence. The FBI uses electronic surveillance, undercover agents, and informants. Computer data bases and computer models are also used to assess potential violence among known groups.

The scientific information needs include behavioral scientists, psycholinguists, computer experts, and weapons experts, including those knowledgeable in the areas of nuclear, chemical, and biological weapons. the need for such skills at the regional, state and local level could be very great in a future conflict because of the frequent successes that terrorists have had in the last decade and because of the increasing technological complexity of their approaches.

2. <u>Response to a potential nuclear confrontation</u>: A war or the threat imminent of war with a major power would create large and varied needs for scientific guidance to emergency response organizations. These needs have been and are being assessed in many studies far larger than the present one; an in-depth appraisal of these needs are beyond the resources and scope of the present study. The approach herein has been to examine some of the technology-related problems associated with trying to maintain orderly operations at the regional, state, and local levels under threat of immediate attack by a superpower with nuclear weapons and intercontinental delivery capabilities.

This wartime scenario assumes that each region and state has general civil protection plans for responding to emergency conditions. These plans will have included: preparations for handling civil disorders; identification of key regional, state, and local governmental officials to be relocated to designated and fortified emergency operations centers in remote locations; identification of populations and areas at high risk; and identification of potential host areas for population relocation. The plans should also include for each state and city: identification of relocation routes and transportation patterns; identification of essential services and industries that must be maintained if at all possible; identification of essential workers and provisions to support them; and a public information program and materials.

The scenario further assumes that the emergency response system will have 5 to 7 days time to be implemented. This would follow an advanced warning through U.S. intelligence that one or more "trigger events" had occurred, e.g., a diplomatic breakdown, a military buildup, suspicious strategic or technological activities, or evidence of population relocations from enemy cities. The emergency response would be initiated by notification from a high official in FEMA Washington, D.C. to FEMA regional directors. Notification would then pass to other federal officials, governors, mayors of large cities, other governmental employees, major private sector organizations and the public. The notification process may require several repetitions as the degree of tension escalates.

One set of key governmental personnel would probably be secretly notified to go to the haven centers (bunkers) well in advance of a general relocation notice, while a second set would remain in the regional offices as coordinators. For the key federal officials in 10 midwestern states, the designated shelter area is currently in Denton, Texas. Upon arrival, they would be furnished operational instructions and be expected to make decisions affecting the safety and health of the civilian population.

The major activities in mobilizing the general population will depend on whether or not a major relocation is required.[23] If relocation is required, then substantially parallel activities are required in the high risk area and in the host areas. In either case, the initial step should involve making preparations - increasing readiness and improving capabilities. These preparations focus particularly on maintaining public order; but require consideration of several areas:

* Communication - Interagency; public information; emergency electronic equipment; messenger systems, marking systems for shelters, transportation routes, etc.

* Law Enforcement - Security of persons and property; traffic control; provision for prisoners and other institutional residents; staff allocations planning.

* Fire Protection - Prevention measures; training for massive fires, staff allocation planning.

* Health Services - Medical and support personnel; facilities; medicines and supplies; patient care; public health measures, radiological defense personnel and equipment; special care patients.

* Shelter Services - Reception/congregation centers; protection from explosion, fallout, cold. Capacity planning.

* Water, Food, Sanitation Services - Shelters, institutions, relocated populations, essential workers; resource allocation planning.

* Transportation Services - Relocation operation; sustaining operations for relocated population; support for essential services and industry; traffic pattern planning; transportation resources allocation and planning; provisions for strandees.

* Energy Services - Emergency generators, fuels; support to essential services, transportation, relocatees, shelters.

* Training - Mobilization exercises required for efficiency and to avoid panic.

Mobilization with relocation would require a smooth functioning of all of the plans in the above areas. Particularly difficult will be trying to maintain essential services while shutting down nonessential services. Communications will be critical in informing the public, in monitoring the mobilization and relocation, in responding to problems of bottlenecks as they develop, and in providing mutual aid between service groups or different jurisdictions. Communications will also be essential during sustaining operations, particularly if they have to be redesigned substantially because of unforeseen problems or an attack. Transportation services will obviously be critical during an evacuation, but they will also be essential during prolonged sustaining operations for workers in essential services and industries, particularly if they are expected to commute to the city from relocation sites.

A wide variety of scientific guidance and expertise would be needed both by the key officials at the emergency operating centers (EOC) and by those on the scene. Of particular need would be: communications engineers, health scientists (public health; food safety, radiation protection, contagious disease protection); structural engineers; transportation engineers; electrical engineers; and probably geologists and chemists.

Information needed within the emergency operating centers could be the answers to questions about short- and long-term effects of the nuclear war on food, water, air, people, energy supplies, and structures such as homes, commercial buildings, bridges, highways, and roads. Geological experts may be needed to discuss the geological repercussions of such an incident. Sophisticated communications technology experts would be needed to communicate with those on the outside and in national headquarters centers.

The present authors are not knowledgeable about details of the selection process to be used for those designated to go to the emergency operating centers. Clearly, prescreening would be needed. Simple designation by position in an organization chart would seem to be grossly inadequate from a scientific view. Many so designated may not go when the time came, prefering to take care of their families first, while others would not be able to reach the remote EOC. More importantly, unless careful plans are made to have representatives of the wide range of scientific and engineering fields noted above actually in the EOC, it is unlikely that communications could be established with them when needed. It is dubious that political appointees would be able to ask the right questions, supply the right answers, or make the optimum decisions on issues having complex technological components. Similarly, a communications network between local officials and scientists in relocation centers must be prearranged.

The assumptions in the wartime scenario appears to have two major weaknesses. The first is that 5 to 7 days warning time are sufficient to implement even a carefully planned relocation operation. The second is that the warning time could be as short as 30 to 45 minutes in the event of a surprise attack by nuclear-tipped intercontinental missiles, particularly if through the Arctic ice rather than from terrestial bases. In addition, some 20 major U.S. cities are on the sea coasts, susceptible to short range, submarine-launched missiles or nuclear weapons brought into port on surface ships before the missile strike. The disaster response needs could be enormous.

Mobilization of scientific and technological resources on a very large scale has been possible in the past during time of war (e.g., the Manhattan Project of World War II) or in support of some clearly designated national goal (NASA's man on the moon project announced by President Kennedy). Mobilization of resources for environmental, consumer and worker protection which impinge on a wide range of socioeconomic interests has been notably more difficult. Mobilization under vague threats of war will probably be much more difficult than under specific imminent threat of war. Mobilization after the outbreak of nuclear exchange may be most difficult of all because of a breakdown in the sociopolitical structure.

B. Summary Comments on Case Studies

The nature of the scientific and technological needs varied widely between the several cases, as summarized in Table 1. In those cases involving disasters from the more common natural sources (e.g., hurricanes, floods and tornadoes) scientific information needs were both smaller and more routine, both before and after the event, and could be generally well met by existing arrangements. In contrast, in the Mt. St. Helens case (involving a less common natural disaster) scientific forecasting was critical in reducing loss of life, and in the New York City blackout of 1977 (initiated by lightning strikes on complex technology) private sector electrical engineering expertise was critical in resuming operation.

In even greater contrast, cases involving a larger technological component (e.g., Legionnaire's Disease; Medfly) or a clear technological hazard (e.g., Love Canal, TMI) required highly specific scientific, engineering and technological resources to analyze and resolve the problems posed. The Wartime Scenarios, involving increasing levels of technology-related risks, require greatly increasing scientific and technological information and resources.

These cases illustrate that at times scientific and technological information may be needed urgently, may be essential to good decision making and must be communicated in an understandable form to the public. The most consistent aspect of these cases was the need to communicate effectively to the public what was known about the problem, what was being done about it, and how it would affect the lives of those at risk of danger.

These cases also illustrate that FEMA can have scientific information needs at several different points in time on a given case. For example, to evaluate a request to have a given trigger event declared a national emergency or disaster; to plan the emergency/disaster response; to conduct the response operation.

Frequently occurring related aspects are media and political relations. News media tend to focus on the catchy phrase, simple interpersonal conflicts, uncertainty (particularly involving threats to the public or a visible individual). Careful efforts are required by emergency response officials to get accurate information to the public through the media. Local and state government officials, on the other hand, may be extremely conscious of the public relations aspects of a possible emergency that may not happen. They may not want a lot of media attention to it before the fact: adverse publicity may be bad for tourism, efforts to attract industry or new government projects, etc. In contrast, after a disaster has occurred they may welcome publicity in order to maximize federal assistance.

TABLE 1

CASE STUDY SUMMARY

Case Study	Science/Technology Needs
1. Hurricane Camille, 1969	Information needs small. Skills and equipment needed for pest control, communications, transportation.
2. Hurricane Agnes, 1977	Meteorological information used. Skills and equipment needed for food/medicine, sanitation inspections; medical care; shelter provisions; financial aid for recovery.
3. Omaha Tornado, 1975	Medical care needed; communications skills valuable; clean up resources required.
4. Mt. St. Helens Eruption, 1980	Volcanologists; health and environmental effects analysts; meteorologists; clean up resources; public information skills.
5. Kansas City Heat Wave, 1980	Scientific information needs small. Getting health and safety tips to the public and information on acute needs of individuals very important.
6. Legionnaire's Disease, 1976	Microbiology, chemical analysis & epidemiology studies essential.
7. Medfly Controversy, 1981	Entomology, toxicology, public health, environmental impact analysis, chemical and biological pest control methods, economic analysis.
8. Northeast Power Failure, 1965	Electric power generation (commercial and emergency); rescue skills and resources; public information.
9. New York City Blackout, 1977	Electric power specialists; rescue resources; looting and vandalism control; public information.
10. Love Canal Disaster, 1979	Analytical chemistry; toxicology; epidemiology; population evacuation resources; communications with local residents.

TABLE 1 (Concluded)

Case Study	Science/Technology Needs
11. TMI Reactor Failure, 1979	Nuclear power plant engineers and safety experts; radiological health experts, radiochemists; media relations, communications with public.
12. Wartime Scenarios	
a. Terrorism, Sabotage, Vandalism	Needs would vary widely with nature of threat, e.g., from responding to bomb threat to forensic chemistry to psycholinguistics.
b. Nuclear Confrontation	Needs intense for a very wide range of scientific, technological, communications and management skills and resources.

V. FEMA SCIENTIFIC INFORMATION UTILIZATION

This chapter (a) summarizes briefly the missions and roles of selected portions of the national and regional offices of FEMA; (b) examines the current scientific and technological capabilities and practices in view of these missions and roles; and (c) appraises the need for alternative capabilities, resources, or practices to improve, if necessary, scientific guidance.

A. Missions and Roles

FEMA was created in 1979 to bring together in one organization capabilities and mechanisms to mitigate, prepare for and coordinate response to national emergencies and major disasters. The organizational structure of FEMA reflects these goals. Of primary importance to the present study are the National Preparedness Programs Directorate and the State and Local Programs and Support Directorate in FEMA headquarters* and parts of the 10 regional offices. The missions of the various offices and divisions are well reflected in their titles, as seen below.

The National Preparedness Programs Directorate develops national operational plans to meet future and long-term civil emergency preparedness and planning requirements. The National Preparedness Programs Directorate contains: (1) the Office of Resources Preparedness (with divisions of: Natural Resources; Resources Planning; Resources Assessment; and Economic Resources); (2) the Office of Civil Preparedness (with Divisions of Civil Defense; Civil Systems and Industrial Protection); (3) the Office of Mobilization Preparedness (with Divisions of Mobilization Plans; Mobilization Exercises; Civil Security; and National Defense Executive Reserve); and (4) the Office of Research (for whom the present study was performed).

The State and Local Programs and Support Directorate is the focal point for all federal emergency programs as they relate to state and local government. The Directorate works closely with the FEMA regional offices. It is charged with the support of state and local government in their emergency planning, preparedness, crisis management, mitigation, response and recovery efforts. It is FEMA's tactical preparedness and response arm--providing funding, technical assistance, services, supplies, equipment and direct federal support as necessary to state and local governments. The State and Local Programs and Support Directorate contains: (1) the Office of Natural and Technological Hazards Programs (with Divisions each of Natural and Technological Hazards); (2) the Office of Emergency Management Programs (with Divisions for Management Systems Development and Management Systems

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* Other technical components include the Training and Fire Program Directorate, the Resource Management Directorate, an Emergency Operations Unit, and the Federal Insurance Administration.

Support); and (3) the Office of Disaster Assistance Programs (with Divisions each of Individual, Public and Mitigation Assistance, and of Response Planning and Coordination.

Each of the 10 regional offices is structured organizationally in parallel with the State and Local Programs and Support Directorate, and contains technical Divisions of: Natural and Technological Hazards; Emergency Management and National Preparedness Programs; and Disaster Assistance Programs. Each also contains an Office of Emergency Coordination.

FEMA performs its activities directed toward improved emergency and mobilization preparedness under the general provisions of the creating legislation. Its activities in disaster response are initiated upon Presidential declaration following requests from the Governors of affected states. In responding to nationally declared disasters, FEMA (through the National and Regional Directors) plays the major role in disbursing disaster assistance funds, in addition to coordinating the technological and management response.

FEMA would interact with several agencies in the event of emergency or disaster, the degree of interaction with the various agencies would depend on the nature of the emergency or disaster. Federal agencies would include the Departments of Defense, Energy, Health and Human Services, Transportation, Commerce, and Agriculture, the Environmental Protection Agency, and probably others.

FEMA would also interact with several agencies and organizations at the state and local level and private sector relief organizations. Thus, each of the 50 states has an Office of Civil Defense, under the Governor. Each county in the state has a designated Civil Defense Officer, usually the Sheriff. A Disaster Field Office is set up at the site of each Presidentially declared disaster area, usually under the direction of the local Regional FEMA Office, but occasionally two or more regions may be involved. The Army Corps of Engineers, the Federal Highway Traffic Safety Administration, the state-controlled National Guard and the American Red Cross and other organizations provide most of the first line response to the public's safety and comfort needs. Disaster Assistance Centers are set up as needed in the disaster area to serve the public. These may have only 1-2 FEMA people but would also have many other experts to answer questions from the public (e.g., on temporary housing, supplies, financial aid or tax questions). Each FEMA Regional Office has a Disaster Reservist Program. These reservists are on call to provide help at the Disaster Assistance Centers or in other parts of the relief operations. (Retirees from major corporations are a major resource for this Program).

B. Current Capabilities and Practices

In order to gain an approximate understanding of current FEMA scientific and technological information needs, capabilities, resources and utilization practices the project team surveyed or interviewed a substantial number of individuals and organizations. The survey was not intended to be exhaustive nor statistically oriented, but rather to help appraise unfilled needs and to provide information on how these needs might be better met. The survey included the review of printed materials, the u e of a questionnaire and personal interviews by telephone or in person. A copy of the questionnaire is included in Appendix C.

FEMA's scientific and technological capabilities and resources reside in seven general areas: (1) the FEMA headquarters technical staff; (2) the FEMA regional offices technical staffs; (3) FEMA publications and reference materials; (4) the National Defense Executive Reserve (NDER) program; (5) the technical staffs in other federal agencies, including the Federal Laboratory Consortium (FLC); (6) technical experts at the state and local government levels; and (7) technical experts at private sector organizations. Each of these resource areas is discussed briefly.

1. FEMA Headquarters Technical Staff: Our survey focused on two directorates: National Preparedness Programs, and State and Local Programs and Support. In general, the management and technical staffs of these directorates contain a relatively high proportion of members that came to FEMA recently from other agencies or are new to government service; this situation reflects FEMA's fairly recent formation and increase in responsibilities. We obtained responses from seven divisions, and two office directors in NPP. We obtained three responses at the branch level and four at the division level in SLPS. Information on staff composition was not obtained from three divisions in each of the two directorates.

a. National Preparedness Program Directorate: The NPP has a total staff of about 120 persons, of whom about two-thirds are professional technical staff. The technical staff appears to have been drawn largely from the social sciences field (60-80%), with smaller numbers of engineers and physical scientists (5-10% each), and a few each of several other disciplines such as mathematics, life sciences and psychology. Survey respondents indicated capabilities, experience or access to information in a number of fields such as: computer science; atmospheric, oceanic and geological sciences; electrical, civil, mechanical and transportation engineering; nuclear and radiation sciences; chemistry; physics; economics, social organization and behavior; and communications.

Respondents also indicated similar resources in a great many of the emergency preparedness categories listed. The strengths varied considerably from division to division, as would be expected, but substantial overlap occurred as some divisions indicated capability in over one-third (over one-half in one case) of the categories. One respondent indicated a need for additional expertise in economics/psychology and another indicated needs in a large number of areas.

Most respondents acknowledged few obstacles in obtaining science information when needed, although one noted that possibly they were not sufficiently aware of them. Some respondents said the need for such information was minimal. One respondent (relatively new to FEMA) noted a need for better knowledge of what science information was available and of how to use it. Another noted that better information could contribute significantly, if time only permitted searching it out. One respondent suggested a need for a better directory of science information sources and how to access them; he also suggested that better arrangements were needed for efficient access to computerized data and information centers. Original research would be required to develop some needed information, one respondent said without elaboration.

Only one of the respondents in NPP said his division used the Federal Laboratory Consortium as even an occasional source of scientific expertise, and his primary source of scientific information was the expertise of the several U.S. agencies whose resource plans they coordinate. One respondent said he regarded the FLC as a good potential source of information in case of need, but that the need had been minimal. Two others indicated they hoped to use the FLC in the future, one saying the division was newly organized, and the second saying that he had only recently become aware of FLC's existence. Some respondents indicated they used informal direct contacts with selected laboratories in the FLC.

Respondents indicated somewhat greater awareness of the National Defense Executive Reserve than of the FLC, but only one indicated much use of it. He commented that the executive reservists have the actual experience required to update the government's understanding of current industry practices, as they relate to emergency economic stabilization planning. Another indicated some use of NDER, and a third said he hoped to use it. One respondent commented that he had not thought of the NDER as a source of scientific information, and two respondents indicated a desire for a clearer understanding of the kinds of assistance NDER would provide.

b. State and Local Programs and Support Directorate: The SLPS has about twice the staff number of NPP, with the professional technical component being about one-half of the total. The SLPS technical staff appears to contain about one-half engineers, 20-25% social scientists, 10-15% physical scientists, and small numbers of environmental and life scientists and mathematics/statistics specialists. Survey respondents indicated capabilities, experience or access to information in much the same disciplinary areas as those in NPP, but with more strength in the engineering, physical and environmental fields, in local government and economics. They also indicated capabilities in numerous emergency preparedness categories, with probably the greatest strength in the area of providing shelter to local populations in times of emergencies from natural hazards, fires, dam failures, etc. They indicated more capability in training and education than did respondents in NPP. Two respondents noted they needed additional expertise in areas where they already had some capability.

Respondents in SLPS like those in NPP, acknowledged few obstacles to getting scientific information. One noted that the need for immediate response to brush fire type problems limited the time to get available information, and that FEMA's own library was still getting up to speed.

Another commented that his division augmented its science informational capabilities through use of other federal agencies and a contract with an architectural and engineering firm. One noted lack of good topographic maps, and stream gauging data.

Only one of the respondents used the FLC, but three indicated some direct use of federal laboratories such as the Corps of Engineers Coastal Engineering Research Center. None used the NDER. One respondent commented that the detailed and highly site-specific nature of many of their informational needs made the use of contracts with other federal agencies or private engineering firms preferable to attempts to use the FLC or NDER in developing data and information. Another implied that the information that the FLC or NDER provides was not applicable to his immediate needs.

2. FEMA Regional Offices' Technical Staffs: We requested information from all 10 regional offices, and responses were received from nine; the completeness of the information and data varied. Overall the regional offices apparently have about 500 staff members regarded as professionals, of whom about 275 are disciplined in the sciences and technology. Of those with disciplinary credentials, about 80% are almost equally divided between engineering and the social sciences, about 15% are in the physical or environmental sciences, and a few percent each are in psychology, life sciences and mathematics.

Survey respondents indicated capabilities, experience or access to information in a very large number of fields. The most frequently indicated strengths included: civil, electrical, and some chemical engineering; atmospheric and geological sciences; economics; sociology; computer sciences; and psychology. They also indicated a rather broad and varied emergency preparedness capability. Respondents indicated that experts and publications were available for one-half of the nearly 40 categories at over 40% of the regional offices and for most of the categories in a few offices.

Respondents noted few obstacles to obtaining scientific information. One commented that it was their responsibility to obtain information from the most responsible source; they contacted libraries at other federal agencies and also private corporations. Another commented, however, that "not knowing where to go" for information was an obstacle.

Two respondents stated they used the Federal Laboratory Consortium. One mentioned using the Argonne and Oak Ridge National Laboratories for radiological emergency planning. One respondent replied that the NDER program had been utilized for technical support during national mobilization exercises, while another said they had used NDER to supplement regional staff in emergencies and to survey 36 other agencies for their response capabilities.

3. FEMA Reference Materials: FEMA publishes a wide variety of emergency preparedness and management documents, ranging from technical reports on highly technical research, to training materials and public information materials. FEMA maintains a specialized library of reference materials from many sources focused on aspects of mobilization, emergencies and disasters, and also has lists of references to relevant documents in other holdings.

FEMA's 1982 Publications Catalog listed and gave capsule descriptions of about 460 documents available from FEMA.[24] The documents are divided into several numerical series in the general areas shown in Table 2. Many of these documents were prepared and published initially by FEMA's predecessor agencies. The catalog also lists nearly 200 additional publications of the U.S. Fire Administration that are available through the National Technical Information Service (NTIS).

FEMA Headquarters maintains a computer-retrievable listing of documents in its holdings. A late 1982 printout contained over 2,400 titles, with the computer retrieval number, the name and affiliation of the author or originating organization, and the document identification numbers assigned by the sponsoring agency, the Defense Technical Information Center (DTIC), NTIS or other sources. The year of publication is not always evident on the printout; a sizable percentage of the documents are from the early 1960's, and a few are from the World War II era. The documents are grouped in nearly 100 categories, as shown in Table 3, that describe the range of FEMA's interest.

The FEMA regional offices have smaller numbers of reports and access to the headquarters' library.

Centralized sources of scientific and technological information relating to emergency management have been partially summarized (see Ref. 1, pp. 83-90). The published literature is of course expanding rapidly, particularly that relating to anticipating and assessing the risks of technological and natural hazards and for developing public policy for managing such risks. A few examples include publications by Lawless,[15,25] Thompson,[19] Hohenemser et al.,[26] Sage and White,[27] Petak and Atkisson,[28] Conrad,[29] Porter and Rossini,[30] Carley and Derow,[31] and two reports by committees of the National Academy of Sciences.[32,33]

4. The National Defense Executive Reserve: The NDER is a program established in 1955, and now administered by FEMA for developing a cadre of experienced civilian executives who have been recruited and trained to enter into Government service in periods of either peacetime or wartime emergencies. Reservists augment the staff of governmental agencies and could, on occasion, fill executive positions. They are recruited on the basis of their demonstrated managerial, business, professional, and technical skills and experience. Those entering the NDER become familiar with government programs, priorities and personnel, and are trained in the responsibilities, authorities, policies, and procedures that exist in time of emergency for the agency to which they are assigned. Reservists receive annual training through a combination of materials, meetings, regional and national conferences, and exercises. They are assigned by 3-year terms to designated agencies. Approximately 2,000 reservists were assigned to 17 units within 9 federal agencies as of mid-1982. Agencies most active in using the NDER have included the Department of Commerce (particularly the Office of Industrial Mobilization, but also the Maritime Administration and the Office of Export Administration), the Department of Transportation, FEMA itself, and the Department of Interior (particularly the Emergency Minerals Administration).

TABLE 2

CATEGORIES OF TITLES IN FEMA'S PUBLICATION CATALOG[24]

- Emergency Planning Preparedness and Mobilization
  - Civil Preparedness Guides for State and Local Civil Preparedness Directors
  - Civil Preparedness Guides, including circulars, reports, memorandums and plans (in specialized areas, relating to civil protection during nuclear attack or nuclear power plant emergencies)
- Emergency Coordination
- Federal Disaster Assistance
- Fire Prevention and Control
- National Flood Insurance Program
- Emergency Management, Training and Education
- Disaster Mitigation and Research
- *Leaflets and Kits*
- FEMA Publications
- Miscellaneous Publications

TABLE 3

FEMA TECHNICAL REPORT CLASSIFICATION CATEGORIES*

Radiological Protection	Blast Protection
Thermal and Fire Protection	BW/CW Protection in Shelter
Materials, Techniques and Systems	Environmental Characteristics of Shelters
Human Factors	Environmental Materials Procedures and Systems
Food Supply	Shelter Water Supply
Shelter Furnishings	Medical Resources in Shelters
Subsistence and Habitability Test Procedures and Systems	Shelter Utility Services
Shelter Auxiliary Systems	Shelter Hardware Components
Shelter Operational Studies	Shelter Occupancy Studies
Training and Guidance Material on Shelter Management	Procedures and Systems For Planning Shelter Management
Shelter Concept Studies	Evaluation of Partial Shelter Systems
Area Wide Shelter Systems	Radiological Information Systems
Radiological Monitoring Systems	Radiological Instruments
Communications and Warning Systems Studies	Communications Studies
Warning Studies	Control of Target Configurations
Damage Limitation	Other Preparedness Studies
Emergency Health Problems	Medical Support Studies
Medical Aspects of Ionizing Radiation	Rescue
Damage Control	Thermal and Fire Phenomena and Effects
Thermal Hardening	Active Thermal Countermeasures
Fire Field Tests	Emergency Operatons Doctrine and Organization
Foreign Emergency Operations Doctrine and Organization	Disaster Research
Fallout Formation and Distribution Phenomena	Radiation Fields
Fallout Contamination Phenomena	Biological Fate of Radioelements in Fallout
Decontamination Methods Development and Testing	Peripheral Post Disaster Radiological Countermeasures
Radiological Recovery Operations Analysis	Prediction of Physical Damage and Debris
Damage Repair and Debris Clearance Methods	Repair Reclamation Operations Analysis
Postattack Health Assessment Procedures	Postattack Dietary Rehabilitation and Welfare Operations
Medical Care Operations Concepts and Procedures	Sanitation, Waste Disposal, Pest and Vector Control
Assessment of Postattack Environment	Recovery of Societal Elements Requirements and Methods
Management of Postattack Operations	Management of Post Disaster Operations
Postattack Sociological and Psychological Studies	Post Disaster Sociological and Psychological Studies
Civil Defense Systems Analysis	Development of Total CD System Evaluation Techniques

TABLE 3 (Concluded)

Evaluation of Crisis-Oriented CD Systems	Analysis of Constraints on CD Systems
Active/Passive Defense Studies	Projections of the Strategic Environment
Relationships in National Security	Vulnerability to Weapons Effects
Total Vulnerability Analysis	Vulnerability of Producing Systems
Vulnerability of Distribution Systems	Evaluation of Civil Defense Organization
Improved Training Effectiveness	Development of Training Programs and Methods
Development of Local Civil Defense Plans	Development of Data Analysis Techniques
Development of Tests and Test Methods	Development of Management Planning Techniques
Development of a Survival Estimating System	Development of Vulnerability Factors
Analysis of the Intelligence Systems	Nuclear Weapon Effects Studies
Natural Environment Data Studies	Social and Psychological Studies
Public Acceptance Studies	Social Systems Under Stress
Communication Processes in Civil Defense	Dam Safety - General
Toxic and Hazardous Materials - General	Studies Common to All Civil/Political Disturbances
Information/Library	General

* Categories listed in a 1982 computer printout of FEMA holdings.

5. Technical Staffs in Other Federal Agencies: Most of the cabinet level departments and the executive, congressional, and independent agencies within the federal government contain substantial percentages of staff with scientific and technological expertise. These staff members are widely distributed among mission and regulatory units engaged in training, information compilation, intelligence analysis, laboratory and field research, technology transfer efforts, design and construction projects, regulatory activities, remedial actions, strategic analyses and policy review. The expertise included in these units is not all accessible to FEMA nor necessarily of significance to FEMA's emergency and disaster response responsibilities. Collectively, however, the scientists and engineers in the offices and laboratories of these units provide an enormous resource.

Of particular value in time of emergency or disaster may be elements of Departments of Health and Human Services, Energy, Defense, Transportation, Commerce, Agriculture, Interior, and Labor and such agencies as the National Aeronautics and Space Administration and the Environmental Protection Agency. A description of all the relevant expertise in all these elements is beyond the scope of the present discussion, but special note of a few of them and of the Federal Laboratory Consortium is warranted.

a. Federal Laboratory Consortium (FLC): The FLC was established in 1974 to improve technology innovation and to make more effective use, through technology transfer between federal governmental units, of the results of the government's investment in scientific and technological research and development. The FLC evolved from the Department of Defense's 1971 intiative in establishing a technology transfer laboratory consortium to improve communications between DOD labs, and (through a cooperative agreement with the National Science Foundation) a liaison service to improve communications with other agencies.* The role and responsibilities of the FLC were further defined in the Technology and Innovation Act of 1980.

The NSF's Intergovernmental Science and Public Technology Division and DOD's Naval Weapon's Center, China Lake, California have provided resources for operation of the FLC.** A Federal Laboratory Consortium Resource Directory was issued in November 1979.[34] It listed 197 member laboratories in six grographical regions in the United States. The distribution of these laboratories by state and region is shown in Figure 1. The Directory also provided names, addresses, and telephone numbers of 90 member representatives to FLC, described relevant areas of application and expertise in considerable detail for each of 78 of the member laboratories, and provided an index of application areas. In late 1982, FLC had over 200 members and a list of designated technical representatives for 101 of them.

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* NASA had initiated a major program during the 1960's to improve transfer of its technological developments to the private sector.

** The Intergovernmental Program Section of ISPT, NSF is currently headed by Edward T. Kelly (telephone: 201-357-7560). The Executive Director of the FLC is Mr. George F. Linsteadt and the Naval Weapons Center (telephone: 714-939-2305).

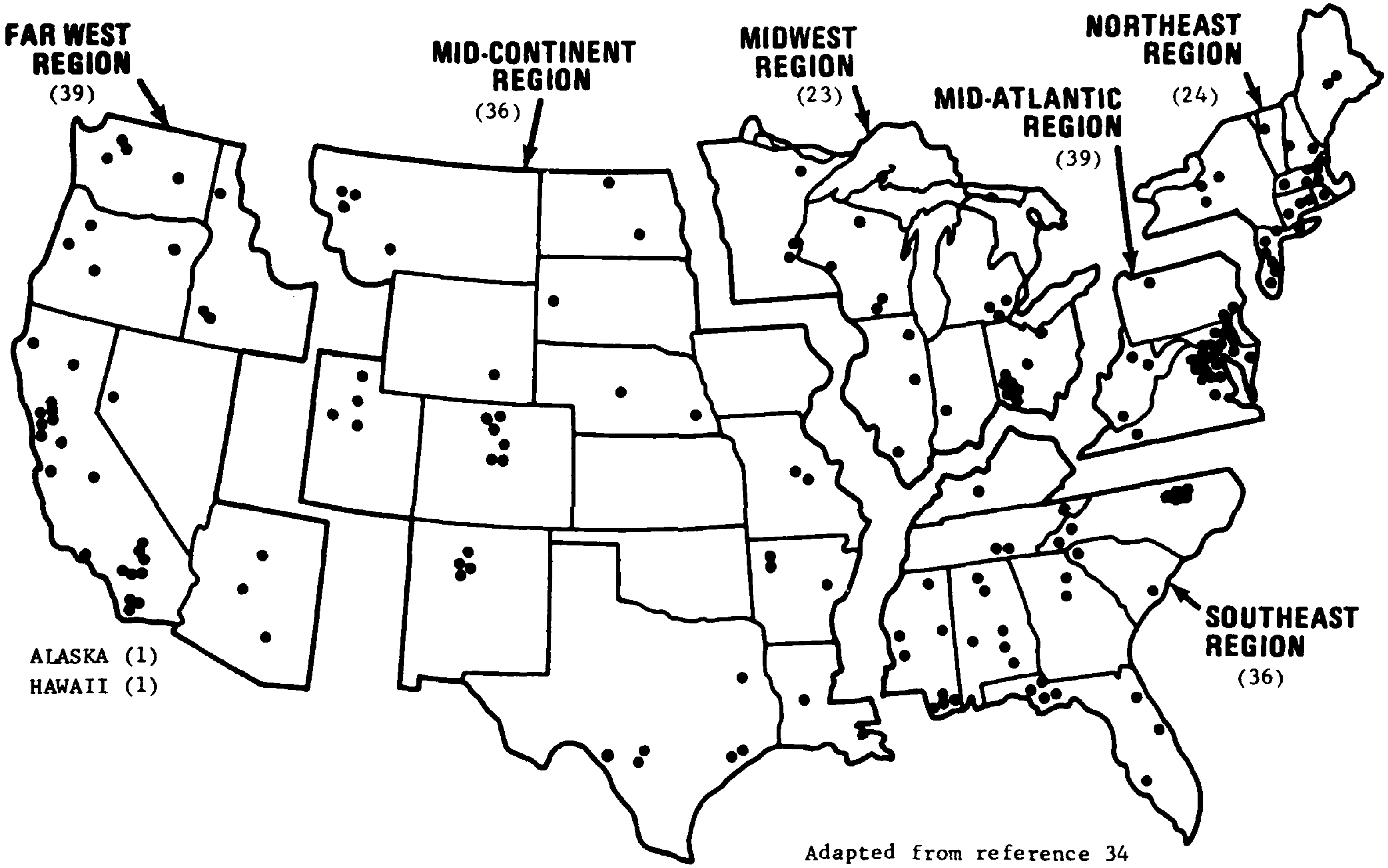

Figure 1. Geographical Distribution of FLC Member Laboratories (1979)

The FLC published a directory of all federal laboratories (including both FLC members and nonmembers) in 1983, but this document was not available for the present study. Reportedly, it does not describe capabilities of the laboratories.

b. Specific federal agencies: Many of the federal agencies having scientific and technological expertise were referred to under the FLC membership above, but further mention of a few of them is warranted.

(1) Department of Health and Human Services: DHHS has an important role in the nation's overall emergency and disaster response program, and portions of it provide an exceptional resource of scientific expertise. The DHHS has specific plans for both national emergencies and natural disasters in each of the 10 federal regions.

The DHHS emergency plan for Region VII (headquartered in Kansas City, Mo), for example, provides directions and information for regional executives in order to promote readiness, protect resources, and survive with a group able to reconstitute regional government. The plan divides staff into two groups: one to remain in Kansas City and another to relocate to the Federal Regional Center in Denton, Texas, once an advanced alert is declared. The initial phase of the plan calls for activation of regional alert network and creation of an emergency operating center to monitor the situation. Once an advanced alert is declared, the alerting network is activated to notify employees and send on those assigned to Denton. The plan does not, however, specify inclusion of any scientific personnel either at Federal Regional Center in Denton or in the local office. Following a nuclear attack, the plan directs DHHS staff to help state and local officials in meeting needs for lifesaving, emergency health, and welfare services. The priorities for activity then are personnel survival and building protection, executive continuity, and restoration of administrative services. The plan also calls for provision of medical, sanitation, or radiation monitoring services as part of personnel survival and building protection.

The DHHS disaster assistance plans for the regional officer states that primary responsibilities for disaster relief rests with state and local agencies. Federal assistance will be provided through DHHS to supplement those services when either the states or FEMA require assistance, whether or not the situation is officially declared a natural disaster. The DHHS plan calls for the following assistance: regular reports on disaster activities to the regional director who communicates with FEMA, other federal offices, and the press; designation of two DHHS engineers to help FEMA assess damage; assistance in assessing threats from communicable disease or other health hazards; counseling services; and an assessment of damage to health facilities.

(a) Public Health Service: The PHS contains three major elements of interest here: the Center for Disease Control; the Food and Drug Administration; and the National Institutes of Health.

The CDC is a major source of information and assistance during emergencies. CDC is called in by state and local health officials when medical/health problems are beyond local capabilities. CDC played a role in many of the case histories reviewed earlier in this report. For example, staff from the CDC's Center for Environmental Health provided immediate assistance at Three Mile Island, Mt. St. Helens, the Love Canal, and numerous other toxic waste sites. CDC staff also came to Kansas City following the heat wave in 1980 to assess those residents most at risk during prolonged heat to allow city officials to make better plans should the situation recur. Staff from CDC's Center for Infectious Disease were instrumental in determining the origin and treatment of Legionnaire's Disease. CDC staff is readily available to assist in these kinds of cases. Only about half of the CDC's 3,500 employees are assigned to the main facilities in Atlanta, Georgia. Some, for example, work in the National Institute for Occupational Safety and Health at Rockville, Maryland, Cincinnati, Ohio and Morgantown, West Virginia. Others are assigned for two years as field officers at state and city health departments throughout the country.

The CDC staff and FEMA staff who have worked with CDC feel that there are almost no areas of emergency medical expertise that CDC staff could not address. The broad range of CDC activities and varied background of CDC staff gives CDC a wide range of information and access to non-CDC medical experts. This resource provides FEMA excellent support for health and medical care issues in disaster management.

Food and Drug Administration: The FDA is the Government's primary agencies for monitoring and regulating the quality of foods and beverages, medicines and pharmaceutical drugs, and cosmetics. It contains a large number of scientists and experienced technical personnel. The FDA is directed in emergencies to dispatch field personnel to assist local officials in locating surviving stocks of medication, to assess useability, to prevent distribution of contaminated food and drugs through visits to food and drug processes and distributors, and to collect and analyze samples for radioactivity.

National Institutes of Health: The NIH is a nonregulatory agency dedicated to research on human health needs. The several institutes within NIH contain a very large number of biological, medical, and life scientists, although most of these specialists are not trained in emergency disaster or response. The National Institute of Mental Health (within NIH) has recently established a center for mental health studies of emergencies.

(b) Social Security Administration: The Social Security Administration district office is instructed to report on damage to people and property and to represent HHS until FEMA creates a field office. SSA staff is also instructed to help survivors, settle survivors claims, and obtain disability benefits, supplemental social security or family assistance for those eligible.

(c) Regional Operations for Facilities, Engineering and Construction: ROFEC will provide architectural and engineering services for damage surveys, cost estimates, and facility safety during emergencies, regardless of whether the federal declaration is made. If the federal declaration is made, ROFEC is also authorized to assess damage to school buildings and to provide architectural and engineering services for new school construction or repair to existing schools.

(2) Department of Energy: DOE has a large number of scientists and engineers on its staff. In addition, it contains a valuable source of scientific expertise in the staffs of the several national laboratories within it, such as those at Oak Ridge, Tennessee; Argonne, Illinois; Livermore and Berkely, California; Los Alamos, New Mexico; and Brookhaven, New York. The DOE staffs have particular expertise in radiation protection and electric power production and distribution.

(3) Department of Defense: DOD has numerous Army, Navy, and Air Force laboratories devoted to basic and applied research in support of its missions, in addition to its purely military units. The research of these laboratories range from medical to materials and electronics, and from explosives to chemical, biological, and nuclear warfare. The Army Corps of Engineers is frequently involved in disaster response efforts, while the Chemical Corps and Ordnance Corps may be of assistance in emergencies involving chemicals or explosives.

(4) Department of Transportation: DOT has separate administrations for highway (FHWA), railroads (FRA), and air travel (FAA) and the Coast Guard, all of which have expertise for certain kinds of disasters and emergencies.

(5) Department of Commerce: DOE agencies of particular interest to FEMA may include the National Oceanic and Atmospheric Administration, National Weather Service, National Severe Storms Center, and National Bureau of Standards. The DOC also operates the National Technical Information Service, the government's primary source of secondary copies of technical reports prepared by its agencies and contractors. The NTIS holdings may be searched by computer.

(6) Department of Agriculture: USDA has a series of four regional research laboratories in addition to several relevant line components such as the Forest Service, and the Science and Education Administration, the Office of Transportation, and inspection services for animals, plants, and grain.

(7) Department of Interior: DOI's components of interest to FEMA activities are the U.S. Geological Survey, the Bureau of Mines. The Fish and Wildlife Service may be of interest in certain situations.

The United States Geological Survey is responsible for assessing natural disasters and potential hazards and informing both government officials and the general public about potential consequences. USGS staff uses three different kinds of informational statements to do this. The first is a direct statement, usually made in a press release, concerning occurrences such as unusual seismic activity or a plume sighting at a potentially active volcano. The second type of statement is an explanation of behavior of geological events. This is usually provided through background information packages distributed to the press and then supplemented with an interview with USGS spokesman. The third type of informational bulletin can be a forecast or prediction of likely geological occurrence such as an earthquake, landslide, volcano and/or some types of water-related events.

Once the presidential declaration of a disaster is made, USGS no longer communicates directly with the public or the press on the subject of the occurrence. Instead, they work through the FEMA coordinating officer and his or her public information staff to present relevant information. They provide their scientific guidance directly to FEMA and state and local government officials working to manage the disaster and recovery. Only after the disaster has officially been declared over, USGS returns to direct communication with the public and government officials in charge of monitoring potential disasters. USGS played an important role in monitoring Mt. St. Helens and later helped FEMA staff provide thorough and useful information to area residents as discussed in a case study.

(8) Department of Labor: DOL's Occupational Safety and Health Administration contains expertise in protection of workers against high energy sources (electromagnetic and particle radiation), harmful chemicals, electrical shock, excessive noise, etc.

(9) Environmental Protection Agency: EPA contains a number of component laboratories and staff that engage in evaluating the human health and environmental hazards of oils, chemicals and other environmental contaminants. The increasingly frequent recurrence of near-disasters from such sources has increased the interactions between FEMA and EPA, e.g., in the relocation of some 2,000 residents from Times Beach, Missouri, in 1983.

(10) National Aeronautics and Space Administration: NASA has a series of research and flight centers that contain a large number of scientists and engineers in a wide range of disciplines.

(11) Nuclear Regulatory Commission: NRC is the government's primary regulatory unit for nuclear energy and related hazards.

(12) Other Agencies: The Federal Bureau of Investigation in the Department of Justice is an obvious potential source of information for emergencies involving vandalism, sabotage and terrorism. The Veterans Administration, especially in its hospitals, contains medical expertise, equipment and facilities. The Tennessee Valley Authority has many engineers and scientists knowledgeable about electric power and also environmental problems.

6. <u>State and local government</u>: MRI interviews with present and former federal officials indicates that FEMA would expect only occasional scientific assistance from state and local government personnel, but would rely on them more for information on local conditions, as nonscience resources and in implementation of plans. The National Guard units in each state are often called by the Governor in responding to natural disasters or emergency crowd control situations.

MRI contacted 13 governmental units or government-related organizations. State and local government units have quite limited scientific and engineering expertise, mostly directed toward routine operations. State governments usually have, however, an emergency planning or services officer to assist city and county governments, to respond to a disaster and to coordinate state level and private agency assistance, much as FEMA directs the federal response.

In California, for example, the Office of Emergency Services is a part of the Governor's office. Created in 1950 as the State Office of Civil Defense, its name and functions have changed as its staff became more involved in national disaster operations. Currently, its director serves as both state director of civil defense and emergency planning.

As part of preparation for disasters, OES in California has developed and regularly updates plans for air pollution, earthquakes, emergency public information, fire and rescue, floods, law enforcement, medical emergencies, nuclear blackmail, nuclear power plant incidents, oil spills, radiological defense, radioactive material incidents, utility interruptions, and statewide warnings. The office also offers assistance in developing local emergency plans and continuous communication systems, along with training programs, and public information materials and presentations.

As part of response and recovery from a disaster, the California OES assists in: assessing damages; directing and coordinating local, state, federal and private organizations; coordinating mobilization of state and local fire fighting resources; assisting law enforcement and riot control; coordinating search and rescue efforts; and sharing the cost of repair to buildings, streets, bridges, and other public property. A mutual aid program supports the office since most cities and all 58 counties in the state have adopted a master mutual aid agreement to assist each other in emergencies.

Membership organizations devoted to providing exchange of information on common interests and mutual assistance are an important part of the resources of state and local governments. Some of these are potential sources of assistance to FEMA during emergencies, as noted briefly below.

The Council of State Governments has a strong information exchange program with its State Information Center. They also have an Interstate Consulting Service to help states in management problems by sending in training staff for short periods of time.

The National Association of Towns and Townships provides information services and distributes safety and emergency management information on topics such as floods, winters storms, hurricanes, smoke detectors, and drinking water. Many of these are published by FEMA.

The National Association of Counties, which previously produced a number of publications for FEMA, now concentrates on guiding member counties in developing emergency management policy. A subcommittee of members meet periodically to suggest policy for county governments on the topic.

The National Governors Association also distributes publications on similar subjects such as national emergencies and terrorism to members on request. Currently, however, staff reported no special activities to provide scientific or technical information. The NGA made a series of about 30 case studies of responses to natural disasters a few years ago, but the report is not widely available.

The Academy of State and Local Government, in Washington, D.C., operated a Natural Disaster Recovery and Mitigation Resource Referral Service, supported by FEMA and NSF until late 1982. The service acted as a clearinghouse for disaster-related information and conducted case studies focusing on mitigation and recovery from natural disasters. The service may be continued privately on a fee-for-service basis.

The International City Management Association, a membership organization of city administrators, is currently working with the Academy of State and Local Governments to design a computerized information system to allow cities access to a national information bank on topics related to emergency preparedness. The organization has prepared a needs assessment for FEMA of what kind of information cities need for emergency preparedness. In addition, this group provides training programs for city and county administrators on emergency preparedness.

The National Association of Regional Councils, the National League of Cities, and the U.S. Conference of Mayors are primarily prepared to refer members to the appropriate federal agency in case of disaster and to assist in their requests for federal assistance. All these groups also offer members services such as technical assistance on government-related topics, and information exchange lobbying.

MRI also contacted several national organizations that draw membership from public offices and institutions that might be involved in emergencies or disasters to see if they provided scientific information. Staff at the American Association of School Administrators, American Public Power Association, American Association of Port Authorities, American Public Transit Association, and the International Association of Chiefs of Police said that these groups had little to offer either in direct service or scientific guidance during emergencies. These groups, all based in Washington, D.C. area, represent their members before the federal government and provide membership services such as information exchange, document retrieval, and referral to other agencies. Their usual emergency management suggestion is to contact FEMA. On occasion, and only in some areas, the staff of these groups said they could provide a staff who could offer information and/or expertise in a specialized area needed during disaster management related to a members' particular problem via telephone.

7. Private sector organizations: The private sector contains a substantial number of organizations that are either already involved in disaster and emergency response or are potential sources of practical, technological and scientific assistance at such times. Of particular interest are the staffs and special programs at several industries, universities, charitable organizations and professional societies.

a. Industrial organizations: American business and industrial firms in the aggregate contain tens of thousands of scientists, engineers, physicians and other professionals. Most of these are not trained for response to national emergencies or disasters. They do comprise, however, an enormous pool of expertise that should be considered, particularly for technologically-related hazards. While these experts are not generally known to nor readily accessible to the national FEMA staff, many of them would be known to and possibly accessible to local governmental authorities.

Many industrial technologists are well-versed in the state-of-the-art of specific technologies (if not in the forefront of its development), instrumentation and current industrial practices. Most work on problems of direct economic interest to their firms, but a great many work for contracting and consulting firms that routinely assist government agencies to identify, analyze and resolve their problems or otherwise meet their responsibilities. These firms include both private, commercial companies and not-for-profit research organizations and institutes. Two unusual library resources are in the Emergency Management Studies Program of Battelle Research Institute (Seattle, Washington facilities) and the Hazard Information Center of SRI International (Arlington, Virginia offices).[1]

Industrial firms in most large technological categories tend to join together in trade associations, many of which have as one of their goals the improvement of industry safety performance. They may set standards, and provide technical information or assistance to member companies to implement in their practices and products. Most of the standards for safety in such areas as radiation, electricity, heat, noise and chemicals, for example, were provided by industry groups until the last decade or so.

A few of the trade associations are prepared to provide rapid information assistance to governmental agencies or the public on emergencies involving products of their member companies. For example, the Chemical Manufacturers Association provides its CHEMTREC "hotline telephone service" for callers who need rapid information on emergencies involving chemicals, e.g., fires, major spills, sunken barges of chemicals, and other accidents. The National Agricultural Chemicals Association serves as an information exchange facilitator between callers and pesticide producers. The American Petroleum Institute, Gas Research Institute and Electric Power Research Institute could probably provide similar assistance in contacting technical experts either within their staffs or in member companies for problems involving oil, gaseous fuels, or power generation.

b. Universities: The universities and colleges contain one of the largest groups of scientific and technological expertise in the United States. They vary considerably in the range and size of the disciplinary departments they contain and in the experience of their staffs, but the large universities usually have a very large number of departments in the physical, biological, environmental and social sciences, engineering, and public health, for example. These faculty members are usually oriented toward teaching and research. Few are trained in emergency and disaster response. Most are not readily identifiable by FEMA, and if accessible, may not be available on short notice for a substantial level of effort. Local emergency response authorities, however, are familiar with and may occasionally call upon some of these experts, and a few of them have national reputations for their work in identifying and analyzing natural and technological hazards.

Disaster research centers have been established at a few major universities. These include the Natural Hazards Research and Applications Information Center, University of Colorado; the Disaster Research Center, Ohio State University; and the Institute for Disaster Research, Texas University. These centers act as information exchange points, prepare bibliographies of selected research, and perform some original research. A few universities may have emergency preparedness centers. The medical schools associated with several hospitals act as poison control centers in providing emergency assistance and in collecting data and information on poisoning incidents.

Special expertise of interest to FEMA is widely scattered in a few universities. For example, Professor Jiri Nehnevajsa at the University of Pittsburg is known for studies of civil defense problems. Professor Robert Kupperman at Georgetown University (Washington, D.C.) is known for studies of terrorism, Professor Emando Nutley at St. Louis University for earthquake research and Professor Gilbert White at the University of Colorado for research on floodplain problems. Professor Sal Balardo, School of Business, State University of New York at Albany, has set up a computer system to help county governments supplement their local emergency preparedness planning. Microcomputers in the county offices tap into a larger computer at the university and allow the local officials access to evacuation plans of the state and other counties to health facility information, and to preparedness planning throughout the state. The system also provides graphics and maps to visualize areas involved. This system has been created under a grant from FEMA and was expected to be operational June 1, 1983.

c. Charitable organizations: The role of private charitable groups is generally one of providing immediate relief and long-term assistance following disasters or emergency situations, not scientific or technical information. Three major organizations contacted by MRI are discussed briefly below.

The American Red Cross often takes the lead in coordinating the participation of volunteer community groups. When disasters threaten, Red Cross local chapters often help government agencies disseminate official warnings and coordinate resources for voluntary evacuation. Once disaster hits, local chapters mobilize volunteer forces to bring in goods for relief efforts such as food, clothing, bedding, furniture to help staff community shelters. Their staff also provides medical and nursing aid, blood and blood products, and transportation assistance. They also provide immediate help to individual and families by making welfare and other kinds of assistance eligibility inquiries. The Red Cross also often provides longer-term financial aid for families who do not qualify for federal or local governmental assistance. The first half of 1983 saw an unprecedented series of natural disasters in the United States that have severely strained the resources of the Red Cross and required strenuous fund raising efforts.

The Salvation Army also provides immediate help with food, clothing, and temporary shelters in case of disaster. Volunteers also provide communications vans, radios, and emergency generators, working with FEMA coordinator. Staff also provide counseling and longer-term supplies such as furniture and housewares. The Salvation Army has no specific plans in case of nuclear or national emergency.

The Mennonite Disaster Service also works with both of these national organizations and their local chapters to send volunteers to the scene of emergencies. The Mennonite volunteers usually concentrate on providing labor forces to help with the clean up of the aftermath of disasters and to rebuild homes and businesses.

Several other religious and charitable organizations also provide relief assistance at times of critical need.[1]

7. Professional societies: Professional societies exist for almost every disciplinary field of study and for a remarkable number of subfields. Examples include the American Medical Association, American Institute of Chemical Engineers, American Meteorological Sciety, American Institute of Industrial Hygienists, and American Geological Society, to name but a few. The larger of such organizations usually have a permanently staffed headquarters office to assist in routine society activities (e.g., publications), and to act as a focal point for interactions with the public and government. Many also have active local chapters that maintain lists of members and information on members with special expertise. In addition, the federally chartered National Academy of Science and National Academy of Engineers (with headquarters in Washington, D.C.) can provide assistance in a wide range of areas through their committee structures and abilities to attract many nationally known experts to participate on committees.

C. Needs Appraisal

An appraisal of the scientific and technical expertise needs of FEMA in times of emergency and disaster must examine two factors: (1) the identity of resources in addition to those already existing, and (2) accessibility of those additional resources.

1. Resources needed: Resources to be considered are primarily staff, but also includes other resources such as information and equipment.

a. Staff resources: A wide range of technical expertise exists in FEMA's Headquarters and regional staffs. Many of these staff members came to FEMA from FEMA's predecessor agencies or from other organizations involved with emergency or disaster response. A significant (but undetermined) number, however, have joined FEMA from other government or non-government positions that had little involvement with such response.

FEMA's multidisciplinary staff varies considerably between directorates, offices, divisions and branches in number of members, in academic backgrounds and in apparent capabilities. For example, the National Preparedness Program Directorate has a preponderance of staff with academic degrees in the social sciences, whereas the State and Local Programs and Support Directorate draws its staff more heavily from the engineering fields than from social sciences. The FEMA Regional Offices draw almost equally from these two academic areas. The capabilities of the Regional Offices are focused much more in the natural hazards area than are those of the Headquarters' staff. The NPPD contains the most capabilities for planning and response involving wartime emergencies and mobilization. Most units in FEMA have or have access to computer science expertise.

The Headquarters staff has relatively few individuals with credentials in the health and medical sciences or the food sciences field; the Regional offices have small numbers of each. Both levels indicated some emergency preparedness capabilities in these areas. A need for more familiarity in working with state and local governments, cited by one interviewee, should not be overlooked; it may exist at all levels. The experience of FEMA staff members in making broad assessments of the potential risks, costs and benefits of government programs to human health, the environment and socioeconomic conditions was not specifically studied, but the number of such staff appears to be small.

One cannot infer too much from numerical differences in academic backgrounds of staff members, since post-academic experience and training of individuals are probably more important in job performance. The physical, biological and environmental scientists and the engineers may have a greater tendency than social scientists to seek scientific and technological information and data from other federal laboratory staffs, the Federal Laboratory Consortium, private sector laboratories and the technical literature (particularly computerized technological data bases). In fact, the technology-oriented FEMA staff members appear to rely for outside help to a significant extent on informal contacts with former associates--an "old boy" network--or to contact an expert that they know by reputation. The technology-oriented staff members may also tend more than social scientists to question, evaluate and place in context technical information from an outside expert. The social scientists, on the other hand, may be more attuned to nontechnological problems involved in emergency and disaster response.

Overall, the mix of technical disciplines on the FEMA staff appears to be reasonably consistent with its missions and its scientific and technological information needs. Some additions/realignments of skills as indicated above may be advantageous.

b. Other capabilities: FEMA survey respondents specifically stated little need for additional resources for acquiring scientific and technological information. One respondent sagely suggested that perhaps they didn't recognize their needs. More importantly, others indicated a need for more knowledge of what information and data were available and where to go to get it.

Thus, an important need appears to be improved communications between FEMA staff members, and between FEMA staff and available resources in other government agencies. For example, the existence of the Federal Laboratory Consortium was virtually unknown to some FEMA staff, and familiarity with (and use of) the National Defense Executive Reserve was quite varied. Some FEMA staff indicated a need for more familiarity with capabilities and accessibilities of other FEMA staff.

In some instances, respondents indicated a need for better knowledge of what had worked (or hadn't worked) in prior emergencies. The FEMA library resources are not well known to some FEMA staff members (particularly in the Regional Offices) or are regarded as in an early stage of formation. Current and continuing efforts to develop this library and to increase its utilization will be helpful to FEMA's mission.

Improved communications with the public during emergencies and disasters is another capability need evident from our case studies and also cited by some FEMA staff. Communications requirements vary from situation to situation, both in technical and social contents, but the communications mangement function is rather consistent. Information releases should be coordinated between national, state and local officials and should be as accurate, honest, reasoned and understandable as possible under the circumstances.

Our survey did not identify any specific equipment needs related to the input of scientific information, but some FEMA staff suggested that greater use could be made of computer capabilities. This resource need will be discussed further below and in the section on options for improvement.

2. Accessibility of resources: While FEMA has a wide range of scientific and technological expertise potentially available to it, much of this expertise is not readily accessible on short notice in emergencies and disasters. This low accessibility has at least three sources: (a) a need for improved communications within the FEMA organization, as already indicated in the preceding subsection; (b) a need for a system of quickly identifying and locating general and specific sources of expertise (including here both people and facilities) in a wide range of problem response areas, both within FEMA and in other governmental agencies and the private sector; and (c) a need for a method to obtain quickly the services of identified

expertise. The second of these items appears to be most crucial: its solution will probably do much to improve communications (the first item) and should also focus attention on the operational need of the last item. The system needed must be able to search and cross-correlate rapidly among a wide range of descriptors that characterize identities, education, training, organizational and geographical location, types of emergencies and disasters, types of problems, etc. A computerized system, as suggested by some respondents, is indicated, and will be discussed further in the next section on options.

3. Summary of needs appraisal: Discussions with FEMA staff reveals a fairly wide range of perceptions of needs for scientific and technical information. While many survey respondents perceived that they had quite limited need for science in their work, others felt that FEMA needed much more science information input. Several reasons may exist for this divergence of views, including the following:

- The need probably varies considerably between different work units and positions at FEMA. This factor is not a problem since we want to focus on FEMA's overall unmet needs--not those of individuals.

- Some difference probably arises because different respondents defined "science" and "needs" different from others. Staff involved in direct response to emergencies may, for example, focus more on immediate equipment needs of hour by hour response on the scene of a disaster. Staff involved in problem analysis and response planning may focus more on scientific and technical information needs.

- The nature of the disaster or emergency will affect the kind, quality, and quantity of information needed. Our case studies suggest that the need tends to be lowest with the more common problems of natural causes such as a flood, and to increase as the technological complexity of the problem increases.

- The need may be much higher in day-to-day activities (especially those involving planning) than in actually responding to a declared disaster.

The range of science and technological needs is very broad. It includes data and information resources, and staff expertise. This study's scope did not include an attempt to identify specific kinds and numbers of scientists that should be added to the FEMA staff. The lists of disciplines and emergency preparedness capabilities in our survey form (Appendix C) reflect the range of potential needs. Budget limitations make it unlikely that all of this expertise could be added to the FEMA staff, even if major emphasis was placed on recruiting multidisciplinary staff. Even if funds were available for such a staff (either in house staff or with outside assistance) effective use of such a resource would require innovations in some operations. Suggestions for such improved procedures are included in Chapter VI.

VI. OPTIONS FOR MEETING SCIENTIFIC INFORMATION NEEDS

FEMA has both continuing, long term and occasional, immediate short-term needs for scientific and technological information, data and expertise. The more constant, long-term needs are filled primarily by staff selection, working arrangements with other federal agencies (including temporary interagency personnel assignments), use of contractor organizations, maintenance of a FEMA library, and access to outside data bases. The intermittent and often unique short term needs are more difficult to anticipate; they are more difficult to meet because of the short turn-around times available for getting and using the necessary information. They are therefore the focus of the present analysis of options for improved procedures. This analysis assumes that a substantially large and varied number of science information resources is the goal, rather than a small group of science policy advisors at national and local government levels, as for example used by the Home Office in the United Kingdom.[35]

A Personal Contacts System

At present many FEMA staff members contact a set of personal acquaintances within FEMA and other government agencies and laboratories when faced with a need for scientific and technological information and data. This "old boy network" appears to work well at times. Because a situation may dictate a short turn-around time, and a high specificity of information needed (among the multiplicity of skills potentially available), a well developed "old boy network" may be the most effective system possible in certain emergencies or disasters.

The effectiveness of such a system may vary greatly, however, with the particular FEMA staff members involved. It may not work well at all with members who have recently arrived at the agency from positions that did not involve disasters and emergencies. It may work less well in the future (unless it is cultivated) than at present as the percentage of "old timers" on the FEMA staff decreases, i.e., staff who came to the agency from other federal agencies, national laboratories, etc.

The effectiveness of a personal contact system within FEMA itself could be improved significantly by several means. These include holding a series of intra- and inter-unit (directorates, offices, divisions, branches) technical meetings, seminars, conferences, etc. Such meetings may be particularly helpful to staff members in the Regional Offices; they are more isolated from the Headquarters' staff members and from each other. Conversely, however, they may have greater knowledge of the requirements for working effectively with state and local governments and with the public, and could share this knowledge with Headquarters staff. Such meetings should combine considerable opportunity for informal personal interactions as well as more formal discussions of problems and activities of mutual interest. These meetings may be much more effective in transferring information about lessons learned during an event than would a typical report of it filed in headquarters.

B. Directories of Government Resources

The existence of a wide range of scientific and technological expertise in federal government agencies was noted in the previous chapter. The existence of the Federal Laboratory Consortium in which the scientific components of many of these groups maintain membership was also noted. The FLC itself seems not to be widely used, however, by FEMA staff as a source of information. FLC issued a directory of its membership in 1979 and is said to be about ready to issue a new edition. Greater distribution and awareness of this new directory may increase the use by FEMA staff of the directory, the FLC and its member laboratory staffs.

Overall, however, FEMA staff may need a directory more focused on emergency/disaster related information than is the FLC directory. Such a directory could, perhaps, be advantageously modeled after a recent book Information, USA.[36] This publication lists information sources in some 10,000 offices in federal government agencies. For example, capsule descriptions of some three dozen or so FEMA programs, centers and facilities (including addresses and telephone numbers) are given in seven pages. The book is indexed, so that programs in other agencies of interest to FEMA staff can be located (e.g., the volcano hazards program in DOI; the "countering terrorism" pamphlet from Department of State). A FEMA emergency management information sources directory could use a similar format, if fully indexed.

Other principles of organization (e.g., by type of information needed rather than by agency) might also be considered.

C. Science Resource Information System

The range of scientific and technological expertise that FEMA staff may require and the urgency with which a specific requirement may need to be met suggest the need for the development of a computerized information system. Such a system could allow FEMA's management and technical staff to seek additional scientific input quickly to evaluate or solve unusual problems.

A Science Resource Information System must be carefully designed to have maximum utility: a readout of 200 names of scientists with expertise on a general topic will not be of much help to a FEMA staff member who needs quick assistance on a specific problem. On the other hand, one cannot put enough of everything into the computer system to meet every conceivable specific need; reasonable compromises must be made between comprehensiveness and ease of use. To be widely used, an information system must be fast and flexible and offer distinct advantages over existing practices. Compatibility with other information systems may also be critically important.

The development of a SRIS appears to be a logical extension of recent interests in the Office of Research, NPP, which have included making audits of information systems, inventories of resources and studies of transfer and dissemination of technical information into and out of FEMA. The development of a computerized data base for science information resources is also consistent with the trend throughout government agencies (e.g., over 100 data bases related to environmental data were identified in a 1977 study[37] of five federal agencies*) and in the private sector. The development of a reliable, useful data base will require careful planning and a substantial investment, but once operational, it can provide superior access to available information.

The Science Resource Information System would augment--not replace--current FEMA practices. The major role of the SRIS in FEMA decisions on obtaining outside assistance in science and technology matters is illustrated in Figure 2.

The detailed development of a Science Resource Information System is beyond the scope of the present project, but several criteria can be suggested for it.

1. Designing the System: The SRIS must meet several needs, many of which may overlap while others do not. A multivariate or multimatrix analysis of parameters may be helpful in deciding what information to include in the computerized data base and how it can be searched.

A primary parameter is the general type of emergency, which may be characterized by the nature of the trigger event, e.g., the different kinds of identifiable natural and technological hazards or wartime situations (e.g., preparedness, survival, revival) would comprise a substantial list of fields for coding. The nature of these fields is suggested by FEMA's missions, roles and organizational structure, and in the preceding discussion of FEMA's capabilities and needs.

Each of these kinds of situations would pose a number of identifiable types of responses, which, in turn, may require one or more kinds of scientific and technological information or expertise. The types of responses may be narrowed by establishing constraints peculiar to the specific event (e.g., what response is appropriate to the threat posed?; what response level is credible or acceptable to the public?; what time limits exist?). Similarly the kinds of information or expertise to be sought may be constrained (e.g., by time limitations, by the technologies involved, by need to have the expert on site; by whether the emergency is "routine," unusual but localized, or of national proportions; by whether FEMA has a lead or support role; and by financial resources).

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* Departments of Agriculture, Commerce, and Interior, the then Energy Research and Development Administration, and the Environmental Protection Agency.

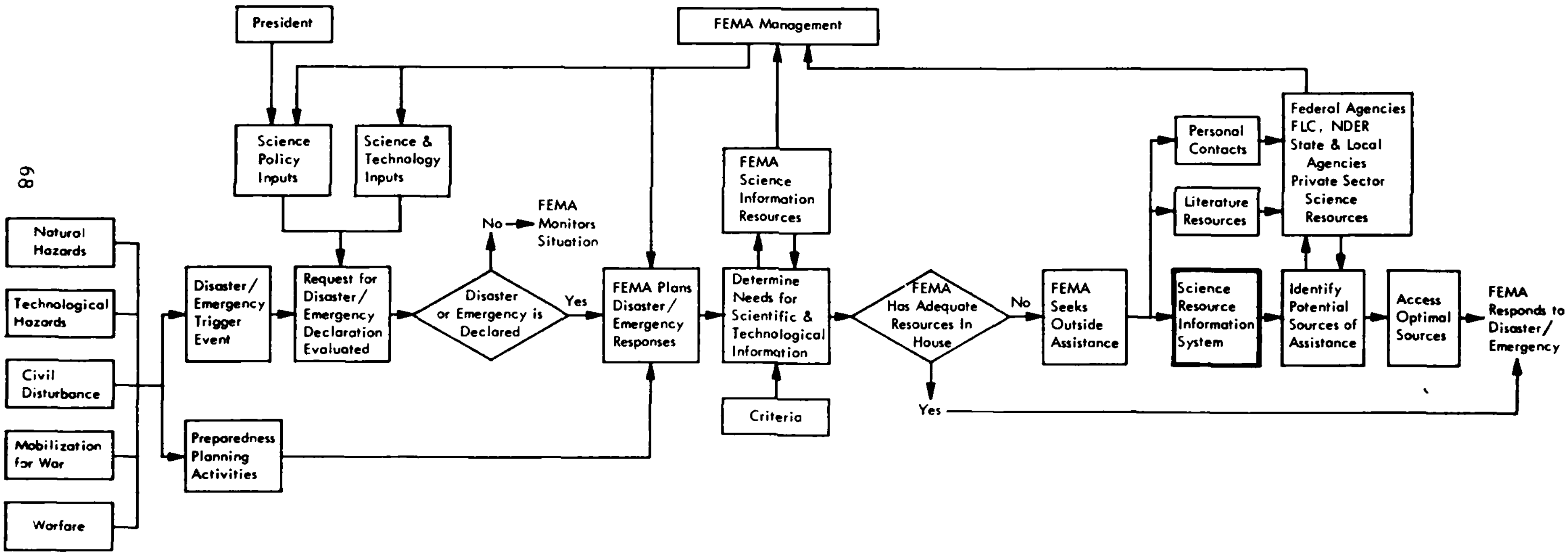


Figure 2 - Role of the SRIS in Science and Technology Input for FEMA.

The identification and characterization of the science information resources are the most critical elements in the system. As indicated previously, these resources may include library resources, knowledgeable personal contacts (inside or outside of FEMA) and other outside experts. While the last item is the focus of the present discussion, consideration of the first two may be helpful in making the computer system as widely compatible as possible. In addition, compatibility with a computer retrievable information system for emergency response equipment may be advantageous.

Individuals must be identifiable by discipline, specialties, geographical location and FEMA Region, kind of permanent position (e.g, FEMA, other government agency, university, industry), type of availability (e.g., telephone contact or on-site resource); how soon available; how long available; existing or prior contractual or consulting arrangements; and addresses and telephone number. Of particular value may be an easy way to identify those with special broad abilities in field expediency. Information on individuals must then be cross coded with emergency response needs.

2. Building the Data Base: After the SRIS has been designed a sizable effort will be required to identify those individuals and other resources for which data are collected and encoded. Individuals may be identified by several methods, e.g., organization charts of government agencies; reputation from prior work or publications; suggestions from FEMA staff or other government agency staff; inquiries at universities and selected research or industrial organizations, etc. Hard decisions must then be made on how many and on whom of the identified sources that data will be compiled and encoded. A tier system may be cost effective, i.e., complete information may be collected for a core group of those most likely to be used, less information on those likely to be used less frequently, and only certain basic information on all others in the system.

3. Maintaining the Data Base: The data base must be reliable and up-to-date if it is to be useful and used. New types of emergencies may need to be added from time to time (e.g., particularly technological hazards) as well as new response patterns and procedures, and new disciplines and specialists. Systematic procedures will be needed to keep information on individuals up-to-date (e.g., annual or biannual contact with the core group members). Pertinent research reports and selected technical journals might be monitored to add significant entries to the data base.

D. National Emergency Science Reserve

Computerized methods for the identification of knowledgeable scientists and experts alone will not be sufficient to provide the services needed. A mechanism must be established to make those services available to FEMA staff on short notice.

Several mechanisms are available to be used by FEMA for obtaining the services of experts who are already employees of the Federal government; these will not be addressed here. Similarly, FEMA has considerable experience in establishing working relationships with state and local governmental authorities and should be able to utilize these mechanisms to get assistance from experts in those agencies, at least for problems in their geographical areas.

The services of scientists and engineers in the private sector will require different mechanisms. One possible approach to such a system would be the establishment of a National Emergency Science Reserve. The NESR would be modeled after the NDER, but instead of recruiting retired executives, it would establish working relationships with both active and retired scientists. They could receive orientation in FEMA's needs and be on call when emergencies arose. Consulting and contractual agreements may be needed if more than a telephone conversation is involved, e.g., the individual may need to get approval from an employer or university, to be assured that time and expenses would be reimbursed, or to be assured that legal liabilities will not be incurred. Such arrangements could be prepared on a contingency basis to enable quick access to this expertise in emergencies.

E. Critical Reviews of Available Information

Considerable documentation exists, as indicated in Section V.B., relating to emergency and disaster preparedness and response. Some of these documents are of quite recent origin, while others are largely of historical interest. The scientific and technological information in this literature covers a broad range of topics. The present study did not attempt to review the content of this literature or to determine how efficiently one can find scientific and technological details of interest. Our survey of titles in the computer printout of FEMA holdings and comments by a few FEMA staff members suggests that considerable effort would be required by FEMA staff receiving responsibilities in new areas to become familiar with prior results in that area.

One method of improving the accessibility of these results would be to prepare up-to-date critical reviews and state-of-the-art reports of many topic areas in this literature. Some reviews and reports of this nature have been prepared from time to time, but we believe a substantial collection of such documents would be valuable assets for FEMA staff and for state and local government employees with emergency responsibilities. Examples might include fire protection research, radiological protection from nuclear power plant accidents, concepts and operation of public shelters, and post attack sanitation measures, to name but a few. In short, documents that integrate the available information and lessons learned on a subject will be more useful than a large number of reports on separate incidents or research projects.

Of special interest, perhaps, to many authorities at the scene of natural and technological disasters would be special collections of case histories of previous related emergencies. These would be more detailed case histories than those included earlier as part of this report; they would be selected to illustrate a wide range of problems that can arise in emergency management, and both more successful and less successful efforts to resolve them. The collected volume should be extensively indexed. Such a collection would appear to be increasingly valuable as FEMA becomes more frequently involved in emergencies and disasters of man-made, technological origin*, particularly if terrorists, saboteurs or vandals strike against complex technologies that affect thousands of lives.

* For example, FEMA became involved this year in the environmental nightmare caused by improper disposal of hazardous chemical wastes at Times Beach, Missouri.

VII. SUMMARY

An assessment of the scientific and technological information aspects of the Federal Emergency Management Agency found that agency has substantial capabilities and resources for meeting its needs, but also found several areas in which improvements appear to be possible, and developed several recommendations for making improvements. This assessment included a combination of approaches for determining FEMA's needs, capabilities and resources. One input was a review of the literature on informational needs and resources for emergency and disaster response agencies. Several previous studies had examined various aspects of these needs and resources and suggested methods for improving the exchange and accessibility of technological information under several circumstances, e.g., data bases, a clearinghouse, and establishment of FEMA.

A second input was a series of 12 selected case studies: five involved previous disasters of natural origin (hurricane, tornado, volcano, and heat wave); two involved emergencies from complex biological/technological interactions (the Legionnaire's Disease and the Medfly incidents); three involved major failures of electrical power production/distribution systems (one resulting from lightning strikes, one from protective devices in the grid distribution system, and one from a nuclear power plant accident); one involved hazardous waste disposal problems; and finally two involved wartime scenarios, one focusing on confrontation with a small power and one with a major (nuclear capability) power.

These case studies demonstrated that a wide range of needs exist for scientific and technological information, expertise and resources in emergency and disaster preparedness and response, mitigation and recovery. Rapid response to these needs is often necessary for effective decision making and resolution of the problems posed by an emergency, particularly those posed by complex modern technologies. These cases also revealed as a common characteristic the need for effective communication between federal emergency response officials and state and local agencies or parties-at-interest, with the media and with the public.

A third input was a series of surveys and interviews with selected FEMA staff regarding capabilities, practices and needs for scientific and technological information related to emergency and disaster preparedness and response. The survey focused on three parts of the FEMA organization: the National Preparedness Program Directorate; the State and Local Programs and Support Directorate; and the 10 Regional Offices. A fourth input to the assessment was a number of contacts with several other government agencies and private sector resources involved in emergency and disaster response.

The survey responses, interviews and other contacts found that the FEMA staff has a wide range of scientific, engineering and other technological expertise. The staff also has available to it outside assistance such as those available through FEMA contracting and consulting arrangements, the National Defense Executive Reserve, the Federal Laboratory Consortium, and to some extent individuals in other federal agencies or in the private sector. FEMA's capabilities and resources are not, however, completely recognized throughout the agency. In part this arises because FEMA is a relatively new organization, in which organizational components and individual staff members have been drawn from several resources, in part because of the substantial range in interests of the different offices and branches of the organization, and in part because the substantial portion of the staff located in regional offices have had minimal opportunity for interaction with each other or with headquarters staff.

Currently FEMA staff appear to obtain scientific and technological input when needed from outside sources through three or four principal routes: (a) literature resources, (b) contractual arrangements; (c) other government agencies with a mandate to work in a closely related area; and (d) a fairly extensive set of personal acquaintances and referrals between FEMA staff and other federal agencies or private sector experts.

Many FEMA staff members seem to feel that their needs for scientific and technological information are being satisfactorily met by these existing routes. In contrast other staff members and some non-FEMA researchers in the disaster and emergency response field suggest that the full need is often not recognized by many FEMA staff members themselves, a large percentage of which have little background in the physical, biological, medical, or environmental sciences. Still other staff members feel that the major unmet needs are in the areas of behavioral science and in knowledge of state and local governments, and in how to work effectively with them. Interestingly enough, the need for scientific and technological expertise may be greater in the day-to-day planning activities of FEMA staff members in Headquarters than in immediate disaster and emergency response situations. FEMA Regional Office staff may need assistance the most when emergencies evolve from complex technologies rather than from natural forces.

One must conclude that the needs probably vary substantially between different units and different positions within FEMA. Some individuals have by education, experience or personal contacts, access to scientific and technical information needed to perform their duties. Others, however, have inadequate access to such resources and the mechanisms available within FEMA should be improved to remedy this situation.

Five options are suggested for improving FEMA's scientific and technological information capabilities to meet its needs. These include: (a) improving the presently existing system of personal contacts; (b) improving directories of emergency and disaster response resources; (c) developing a Science Resource Information System; (d) developing a National Emergency Science Reserve; and (e) preparing critical reviews of available information in selected areas. Each of these is discussed briefly below.

Personal Contacts System: The effectiveness of a personal contact system within FEMA could be improved significantly by several means. These include holding a series of intra- and inter-unit (directorates, offices, divisions, branches) technical meetings, seminars, conferences, etc. Such meetings may be particularly helpful to staff members in the Regional Offices, who, in turn may have greater knowledge of the requirements for working effectively with state and local governments and with the public, and could share this knowledge with Headquarters staff. Such meetings should combine considerable opportunity for informal personal interactions as well as more formal discussions of problems and activities of mutual interest. These meetings may be much more effective in transferring information about lessons learned during an event than would a typical report of it filed in headquarters.

Directories of Government Resources: The FEMA staff could benefit significantly from greater awareness of the Federal Laboratory Consortium Directory and the resources available through the FLC. The staff may benefit even more from having available an Emergency Management Information Sources Directory, with fully indexed information on government agencies, centers, facilities and programs engaged in work related to FEMA's needs.

Science Resource Information System: A carefully designed computerized Science Resource Information System could be of much help to FEMA staff members who need quick assistance on specific problems. Reasonable compromises must be made between comprehensiveness and ease of use in designing the SRIS. To be widely used, an information system must be fast and flexible and offer distinct advantages over existing practices. Compatibility with other information systems may also be critically important. The SRIS would augment--not replace--current FEMA practices. The detailed development of a SRIS is beyond the scope of the present project, but several suggested criteria for it can be briefly summarized as follows.

A multivariate or multimatrix analysis of parameters may be helpful in deciding what information to include in the computerized data base and how it can be searched. A primary parameter is the general type of emergency, which may be characterized by the nature of the trigger event, e.g., the different kinds of identifiable natural and technological hazards or wartime situations would comprise a substantial list of fields for coding. These kinds of situations would require different kinds of responses with different kinds of needs for scientific and technological information or expertise. The types of responses may be narrowed by establishing constraints peculiar to the specific event. Similarly the kinds of information or expertise to be sought may be constrained by several factors. The identification and characterization of the science information resources are the most critical elements in the system. These resources may include library resources, knowledgeable personal contacts (inside or outside of FEMA) and other outside experts. Compatibility with a computer retrievable information system for emergency response equipment may be advantageous. Individuals must be identifiable by discipline, specialties, geographical location and FEMA Region, kind of permanent position (e.g, FEMA, other government agency, university, industry), type of availability (e.g., telephone contact or on-site resource); how soon available; how long available; existing or prior contractual or consulting arrangements; and addresses and telephone number. Of particular value may be an easy way to identify those with special broad abilities in field expediency. Information on individuals must then be cross coded with emergency response needs.

After the SRIS has been designed a sizable effort will be required to identify those individuals and other resources for which data are collected and encoded. Hard decisions must then be made on how many and on whom of the identified sources that data will be compiled and encoded. A tier system may be cost effective, i.e., complete information may be collected for a core group of those most likely to be used, less information on those likely to be used less frequently, and only certain basic information on all others in the system. The data base must be reliable and up-to-date if it is to be useful and used. New types of emergencies may need to be added from time to time as well as new response patterns and procedures, and new disciplines and specialists. Systematic procedures will be needed to keep information on individuals up-to-date. Pertinent research reports and selected technical journals might be monitored to add significant entries to the data base.

National Emergency Science Reserve: Several mechanisms are available to be used by FEMA for obtaining the services of scientists and engineers in the private sector on short notice. One approach would be the establishment of a National Emergency Science Reserve. The NESR would be modeled after the NDER, and the Disaster Reservist Program of the FEMA Regional Offices. It would establish working relationships with both active and retired scientists. They would receive orientation in FEMA's needs and would have completed the necessary consulting and contractual agreements on a contingency basis to enable quick access to their expertise in emergencies.

Critical Reviews of Available Information: Considerable documentation exists relating to emergency and disaster preparedness and response. Considerable effort, however, would be required by FEMA staff receiving responsibilities in new areas to become familiar with prior results in those areas. Accessibility to the available information could be improved considerably. A carefully selected and prepared series of up-to-date critical reviews and state-of-the-art reports of many topic areas in this literature would be valuable assets for FEMA staff and for state and local government employees with emergency responsibilities. Examples might include fire protection research, radiological protection from nuclear power plant accidents, concepts and operation of public shelters, and post attack sanitation measures, to name but a few. A set of documents that integrate the available information and lessons learned on given subjects will be more useful than a large number of reports on separate incidents or research projects.

A special collection of case histories of previous related emergencies would be of value to many authorities at the scene of natural and technological disasters. These detailed case histories would be selected to illustrate a wide range of problems that can arise in emergency management, and both more successful and less successful efforts to resolve them.

The collected volume should be extensively indexed. Such a collection would appear to be increasingly valuable as FEMA becomes more frequently involved in emergencies and disasters of man-made, technological origin, particularly if terrorists, saboteurs or vandals strike against complex technologies that affect thousands of lives.

APPENDIX A

CASE STUDY CONTACTS

Contact	Case Studies
Frances X. Tobin Former Regional Director FEMA Region VII Kansas City, Missouri	Hurricanes Camille and Agnes; Kansas City Heat Wave; Omaha Tornado
Tom Hogan Emergency Preparedness Coordinator City of Kansas City, Missouri	Kansas City Heat Wave
Dr. Virginia Gill Assistant Director of Health Department City of Kansas City, Missouri	Kansas City Heat Wave
Robert J. Adamcik Deputy Regional Director FEMA Region III Philadelphia, Pennsylvania	Three Mile Island; Hurricane Agnes; Legionnaire's Disease
John J. Seggerson Center for Disease Control Atlanta, Georgia	Three Mile Island; Hurricane Agnes; Legionnaire's Disease
Dr. Robert G. Shirrar Epidemiologist City of Philadelphia, Pennsylvania	Three Mile Island; Hurricane Agnes; Legionnaire's Disease
Norman Steinlauf Deputy Regional Director FEMA Region II New York, New York	Three Mile Island; Hurricane Agnes; Legionnaire's Disease
William Brown Community Planner/Natural Hazards FEMA Region X Bothell, Washington	Mt. St. Helens
Joan F. Hodgins Emergency Management Specialist FEMA Region X Bothell, Washington	Mt. St. Helens

Contact	Case Studies
Dr. Chris Newhall United States Geological Survey Vancouver, Washington	Mt. St. Helens
James Bergfalk Former Regional Director Department of Health and Human Services Region VII Kansas City, Missouri	Wartime Scenario
Arthur Doyle Deputy Regional Director FEMA Region I Boston, Massachusetts	Northeast Power Failure; New York Blackout

APPENDIX B

OTHER DISASTER ASSISTANCE ORGANIZATIONS CONTACTED

The American Red Cross, National Disaster Service and local Kansas City chapter
Mennonite Disaster Service
Salvation Army

American Association of School Administrators
International Association of Chiefs of Police
American Public Power Association
American Association of Port Authorities
American Public Transit Association

National Governors Association
U.S. Conference of Mayors
National League of Cities
Council of State Governments
International City Management Association
National Association of Towns and Townships
National Association of Regional Councils
National Association of Counties

U.S. Department of Health and Human Services and its Center for Disease Control
California Department of Health Services

Center for Disaster Management, School of Business, State University of New York, Albany, New York

Mr. George Linsteadt
Executive Director
Federal Laboratory Consortium
Naval Weapons Center
China Lake, California

Mr. Gerrard E. Miller
Science and Technology Coordinator
Federal Laboratory Consortium
Seattle, Washington

Ms. Claire Rubin
Natural Disaster Recovery and Mitigation
Resource Referral Service
Academy For State and Local Governments
Washington, D.C.

Ms. Susan Tubbensing
Operational Director
National Hazards Research and Application
Center
University of Colorado at Boulder

APPENDIX C

SURVEY FORM FOR APPRAISAL OF NEEDS AND CAPABILITIES

SURVEY OF SCIENTIFIC AND TECHNICAL INFORMATION NEEDS AND CAPABILITIES FOR EMERGENCY PREPAREDNESS

By Midwest Research Institute Pursuant to
FEMA Contract EMW-C-0835,
"Scientific Guidance to Emergency Organizations"

This survey has three parts. Section I requests information on the educational backgrounds of the professional staff of the responding governmental division or office. Section II requests information on any recent use by the responding division of the Federal Laboratory Consortium or the National Executive Reserve to supplement in-division staff capabilities.* Section III is a more specific survey of the availability to the responding division of a wide range of science fields, disciplines, and emergency response capabilities.

Please complete and return this survey to Midwest Research Institute with the enclosed mailing label.

Respondent's Name ______________________ Title ______________________
Office or Division ______________________ Telephone No. ______________

I. Survey of Staff in Your Division or Office

Questions 1 to 3 below address the science background of professional staff currently in your Division. Please provide the information requested on the space provided.

1. Total number of people in your division ________.
2. Total number of professional staff ________.
3. Educational backgrounds represented:

Science Field	Number of People Holding Degrees in the Science Field		
	Bachelors	Masters	Ph.D.
Life Sciences	______	______	______
Psychology	______	______	______
Physical Sciences	______	______	______
Environmental Sciences	______	______	______
Mathematics	______	______	______
Engineering	______	______	______
Social Sciences	______	______	______

Please refer to the enclosed survey form for a description of the science fields.

* The Federal Laboratory Consortium consists of about 400 member laboratories from all branches of the government, ranging from agriculture to weapons. The National Defense Executive Reserve is a program operated by FEMA which recruits and trains civilian executives for potential use during national emergencies.

II. Survey of Use of Certain General Sources of Science Information by Your Division or Office

1. Does your Division use the Federal Laboratory Consortium (FLC) Directory to locate sources of science information. Please circle YES or NO.

2. Does the Division go directly to laboratories, which are members of the Federal Laboratory Consortium, for science information. Please circle YES or NO.

3. Does the Division use the National Defense Executive Reserve (NDER) to obtain science information. Please circle YES or NO.

4. What are the principal reasons your Division uses or does not use the FLC or NDER?

____
____
____
____
____
____
____
____

III. Survey of Specific Scientific Information Sources Within Your Office

1. Please complete the following form. Completion of the form should take only a few minutes. Many of the fields and disciplines listed will not be required in meeting the responsibilities of your division or office. We are not looking for specific names of either people or publications. We want only an indication of whether you feel you have sufficient resources to respond to emergencies or disasters in those areas that may require participation by your division or office.

2. Place a check mark where applicable to indicate areas of science information sources that your division needs and has available either within your Division or in other divisions (please indicate which).

We also ask that you indicate the science fields or science fields and disciplines where at times, you need additional sources for science information. Please circle the field or fields and disciplines where you have difficulty obtaining science information either within or outside of FEMA.

3. What are the principal obstacles which hinder people in your Division in their efforts to obtain science information when required?

____
____
____
____
____
____

SCIENTIFIC AND TECHNICAL INFORMATION SOURCES AND CAPABILITIES READILY AVAILABLE TO YOU

Science Fields and Subfields	Disciplines	Information Source[1,2] Experts	Publications
1. Life Sciences			
A. Biological	1. Biology	____	____
	2. Microbiology	____	____
	3. Biochemistry	____	____
	4. Genetics	____	____
	5. Nutrition	____	____
	6. ____[3]	____	____
	7. ____	____	____
B. Environmental	1. Air Pollution	____	____
	2. Water Pollution	____	____
	3. Solid Wastes	____	____
	4. Chemical Spills	____	____
	5. Oil Spills	____	____
	6. ____	____	____
	7. ____	____	____
C. Agricultural	1. Plant Science	____	____
	2. Forestry	____	____
	3. Food Science	____	____
	4. Fish	____	____
	5. Wildlife	____	____
	6. Animal Science	____	____
	7. Horticulture	____	____
	8. Food Adulteration	____	____
	9. Food Distribution	____	____
	10. Poultry	____	____
	11. Agronomy	____	____
	12. ____	____	____

---

[1] Please check mark (√) where applicable to indicate areas of science information sources available within your organization

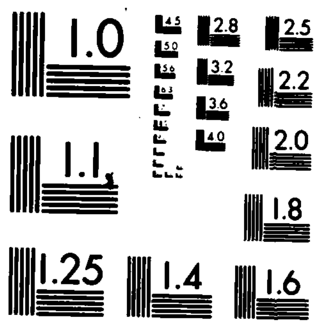
[2] Please circle fields or disciplines where you find or feel that you need additional sources of information

[3] Add other disciplines as needed

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
1. Life Sciences (concluded)			
D. Medical	1. Pathology		
	2. Pharmacology		
	3. Nursing		
	4. Internal Medicine		
	5. Surgery		
	6. Toxicology		
	7. Diseases		
	8. Veterinary		
	9. Gynecology		
	10. Psychiatry		
	11. Radiology		
	12. Dentistry		
	13. Pediatrics		
	14.		
	15.		
E. Other[4]	1.		
	2.		
	3.		
2. Psychology			
A. Biological	1. Behavorial		
	2. Clinical Psychology		
	3. Comparative Psychology		
	4.		
	5.		
B. Social	1. Hysteria		
	2. Industrial Psychology		
	3. Vocational Psychology		
	4.		
	5.		

[4] Add additional subfields and disciplines as needed

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
2. Psychology (concluded)			
C. Other	1. ______	______	______
	2. ______	______	______
	3. ______	______	______
3. Physical Sciences			
A. Astronomy	1. Astrophysics	______	______
	2. Radio Astronomy	______	______
	3. ______	______	______
	4. ______	______	______
	5. ______	______	______
B. Chemistry	1. Analytical	______	______
	2. Inorganic	______	______
	3. Organic	______	______
	4. Physical	______	______
	5. Nuclear	______	______
	6. Forensic	______	______
	7. Ordnance	______	______
	8. Drugs	______	______
	9. Narcotics	______	______
	10. Chemical Warfare Agents	______	______
	11. Insecticides	______	______
	12. Herbicides	______	______
	13. ______	______	______
	14. ______	______	______
C. Physics	1. Acoustics	______	______
	2. Lasers	______	______
	3. Optics	______	______
	4. Nuclear	______	______
	5. Plasma	______	______
	6. ______	______	______
	7. ______	______	______
D. Otner	1. ______	______	______
	2. ______	______	______
	3. ______	______	______



MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
4. Environmental Sciences			
A. Atmospheric	1. Flood	______	______
	2. Winter Storm	______	______
	3. Heat Wave	______	______
	4. Drought	______	______
	5. Dust Storm	______	______
	6. Tornado	______	______
	7. Hurricane	______	______
	8. Meteorology	______	______
	9. ______	______	______
	10. ______	______	______
B. Geological	1. Earthquake	______	______
	2. Volcano	______	______
	3. Avalanche	______	______
	4. Mineralogy	______	______
	5. Earth History	______	______
	6. ______	______	______
	7. ______	______	______
C. Oceanography	1. Biological	______	______
	2. Chemical	______	______
	3. Physical	______	______
	4. Marine Geophysics	______	______
	5. Tidal Waves	______	______
	6. ______	______	______
D. Other	1. ______	______	______
	2. ______	______	______
	3. ______	______	______
5. Mathematics			
A. Mathematics	1. Applied	______	______
	2. Geometry	______	______
	3. Statistics	______	______
	4. ______	______	______
	5. ______	______	______

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
5. Mathematics (concluded)			
B. Computer Science	1. Hardware	______	______
	2. Software	______	______
	3. Information Systems	______	______
	4. Systems Analysis	______	______
	5. Computer Assisted Design	______	______
	6. Computer Assisted Manufacture	______	______
	7. ______	______	______
	8. ______	______	______
C. Other	1. ______	______	______
	2. ______	______	______
	3. ______	______	______
6. Engineering			
A. Aeronautical	1. Aircraft Design	______	______
	2. Guidance Systems	______	______
	3. Aircraft Maintenance	______	______
	4. Aircraft Fueling	______	______
	5. Pilot Training	______	______
	6. ______	______	______
B. Astronautical	1. Space Technology	______	______
	2. Aerospace	______	______
	3. ______	______	______
	4. ______	______	______

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
6. Engineering (continued)			
C. Chemical	1. Petrochemical Manufacturing	______	______
	2. Petroleum Refining	______	______
	3. Chemical Transport	______	______
	4. Hazardous Chemicals	______	______
	5. Waste Treatment	______	______
	6. Inorganic Chemical Manufacturing	______	______
	7. Organic Chemical Manufacturing	______	______
	8. Chemical Storage	______	______
	9. ______	______	______
	10. ______	______	______
D. Civil	1. Architecture Design	______	______
	2. Building Construction	______	______
	3. Road Construction	______	______
	4. Bridge Construction	______	______
	5. Dam Construction	______	______
	6. Sanitation Systems	______	______
	7. Water Distribution	______	______
	8. Rail Construction	______	______
	9. Tunnel Construction	______	______
	10. Transport System, Air	______	______
	11. Transport System, Highway	______	______
	12. Transport System, Rail	______	______
	13. Transport System, Water	______	______
	14. ______	______	______
	15. ______	______	______

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
6. Engineering (continued)			
E. Electrical	1. Power Plant Design	______	______
	2. Power Plant Operation	______	______
	3. Power Distribution	______	______
	4. Electronics	______	______
	5. Semiconductors	______	______
	6. Communications	______	______
	7. Lighting	______	______
	8. Wiring	______	______
	9. Hydroelectric	______	______
	10. Geothermal	______	______
	11. Wind	______	______
	12. Tidal	______	______
	13. ______	______	______
	14. ______	______	______
F. Mechanical	1. Mechanics	______	______
	2. Machine Design	______	______
	3. Production System Design	______	______
	4. Vehicle Design	______	______
	5. Tool Design	______	______
	6. ______	______	______
	7. ______	______	______
G. Metallurgy and Material	1. Coal Mining	______	______
	2. Minerals Mining	______	______
	3. Oil and Gas Production	______	______
	4. Crude Oil Transport	______	______
	5. Natural Gas Transport	______	______
	6. Raw Materials Processing	______	______
	7. Materials Manufacturing	______	______
	8. Materials Transport	______	______
	9. Welding	______	______

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
6. Engineering (concluded)			
G. Metallurgy and Material (concluded)	10. Ceramics Manufacturing	____	____
	11. ____	____	____
	12. ____	____	____
H. Other			
a. Transportation	1. Air Transport Systems	____	____
	2. Highway Transport Systems	____	____
	3. Rail Transport Systems	____	____
	4. Water Transport Systems	____	____
	5. Mass Transit Systems	____	____
	6. Pipeline Transport System	____	____
	7. Postal System	____	____
	8. ____	____	____
	9. ____	____	____
b. ____	1. ____	____	____
	2. ____	____	____
	3. ____	____	____
7. Social Sciences			
A. Anthropology	1. Archaeology	____	____
	2. Ethnology	____	____
	3. ____	____	____
	4. ____	____	____

Science Fields and Subfields	Disciplines	Information Source Experts	Information Source Publications
7. Social Sciences (continued)			
B. Economics	1. Business Administration	______	______
	2. International Relations	______	______
	3. Legal Systems	______	______
	4. State Government	______	______
	5. City Government	______	______
	6. ______	______	______
	7. ______	______	______
C. Sociology	1. Social Structure	______	______
	2. Group Interactions	______	______
	3. Religious Aspects	______	______
	4. Social Welfare	______	______
	5. Demographics	______	______
	6. Social Problems	______	______
	7. Terrorism	______	______
	8. Occupational Health and Safety	______	______
	9. ______	______	______
	10. ______	______	______
8. Emergency Preparedness Capabilities[5]	1. Shelter Design	______	______
	2. Blast Protection	______	______
	3. Thermal and Fire Protection	______	______
	4. Food Supply	______	______
	5. Water Supply	______	______
	6. Medical Resources	______	______
	7. Shelter Management	______	______
	8. Radiological Monitoring	______	______
	9. Warning Systems	______	______
	10. Communications Systems	______	______

[5] This section is provided so that you may indicate the specific areas of emergency preparedness in which your organization has expertise. We realize that each discipline may cover several science fields.

Science Fields and Subfields	Disciplines	Information Source: Experts	Information Source: Publications
8. Emergency Preparedness Capabilities (continued)			
	11. Telephone	____	____
	12. Telegraph	____	____
	13. Radio		
	Stationary	____	____
	Mobile	____	____
	14. Television		
	Stationary	____	____
	Mobile	____	____
	15. Fallout Contamination	____	____
	16. Emergency Medical Care	____	____
	17. Sanitation	____	____
	18. Rescue Operations	____	____
	19. Biological Fate of Fallout	____	____
	20. Medical Aspects Chemical Warfare	____	____
	21. Medical Aspects Biological Warfare	____	____
	22. Rehabilitation	____	____
	23. Fire Prevention	____	____
	24. Social and Psychological Research	____	____
	25. Earthquakes	____	____
	26. Terrorism	____	____
	27. Dam Safety	____	____
	28. Flood Plain Management	____	____
	29. Libraries, Databases	____	____
	30. Training and Education	____	____
	31. Shelter Habitability	____	____
	32. Volcanoes	____	____
	33. Riots	____	____
	34. Demonstrations	____	____
	35. Transportation Systems	____	____
	36. Hazardous Chemicals	____	____
	37. Food Contamination	____	____
	38. ____	____	____
	39. ____	____	____
	40. ____	____	____

Science Fields and Subfields	Disciplines	Information Source	
		Experts	Publications
9. Other[6]			
A. ________	1. ________	____	________
	2. ________	____	________
	3. ________	____	________

6 As needed add other Science Fields, Subfields and Disciplines not elsewhere classified

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FEMA's scientific and technological information needs, capabilities and resources were evaluated through case studies, surveys and interviews. Several options are suggested for improving FEMA's capabilities to meet its needs, including: expanding the presently existing system of personal contacts; improving directories of resources; developing a Science Resource Information system; developing a National Emergency Science Reserve; and preparing critical reviews of available information in selected areas.

KEY WORDS: Emergencies; disasters; science information resources; case studies; survey.

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