May 24, 1957

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TECHNICAL PRESENTATION

For the Joint Committee on Atomic Energy

Hearings on the subject "The Nature of

Radioactive Fallout and Its Effects on Man",

May 27-29 and June 3-7, 1957.

Specifically on:

VI. Atmospheric Transport, Storage, and Removal of Particulate Radioactivity.

VII. Local Fallout.

VIII. Delayed Fallout.

Submitted by:

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BIOGRAPHY OF JAMES G. TERRILL, JR.

Mr. Terrill was graduated from the University of Cincinnati in 1937 with a degree in Civil Engineering. He studied public health engineering at the Massachusetts Institute of Technology Graduate School from 1938-1941. Since 1941 he has been active in the Public Health Service. He participated in the first Bikini Tests. During the period 1948-1951 he studied radiological defense under the sponsorship of the Armed Forces Special Weapons Project at the U. S. Navy Post-Graduate School and the University of California. He has participated in and directed the Public Health Service activities related to the Nevada and Pacific test operations during 1953-1957.

Mr. Terrill is active in radiological committees of the American Society of Civil Engineers and the American Public Health Association. He is a member of the National Committee on Radiation Protection and the Nuclear Standards Board of the American Standards Association.

Presently, he is Chief of the Radiological Health Program, Division of Sanitary Engineering Services, Public Health Service, with headquarters at 4th and Independence Avenue, S. W., Washington, D. C. (Executive 3-6300, extension 5105).

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VI. Atmospheric Transport, Storage, and Removal of Particulate Radioactivity.

Public Health Service fallout activities have emphasized the collection of data on the actual exposure of people which data can be used to modify operational procedures to reduce the exposures and to serve as a basis for studying possible chronic radiation effects.

B. Local Fallout.

Local fallout is initially of concern as an acute external gamma or beta irradiation hazard. For this reason our off-site radiological safety operations in Nevada and in the Pacific are based on external gamma readings obtained with portable survey instruments. This system of operation is based on the assumption that beta concentration during this period are substantially in proportion to the gamma intensities. This assumption has been confirmed, in general, by results of beta measurements of air samples collected during the fallout periods in Nevada. Local fallout may, and has become of concern as an internal beta emitter after its decay to a level at which the gamma irradiation is no longer of concern from the standpoint of acute effects. Up to this time the Service has not attempted to measure alpha concentrations in local (or delayed) fallout although the amounts are presumed to be low.

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A report of local fallout sufficiently detailed to be used for public health purposes is the "Report of Off-Site Radiological Safety Activities" from Operation Teapot conducted at the Nevada Test Site in the Spring of 1955, prepared jointly by the Las Vegas Branch Office of the Atomic Energy Commission and the Public Health Service.[1] Comments concerning the predictability of local fallout and observed patterns of local fallout will be based on this report.

The Teapot report outlines Public Health Service responsibilities and the supporting services, including air support, provided by other agencies.

Data gathered during this operation makes it possible to:

1. Compare predicted fallout with the fallout as it actually occurred;
2. Compare the radioactive cloud path with the deposition of activity on the ground; and
3. Report on observed patterns of local fallout in terms of external gamma radiation.

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[1] Report of Off-Site Radiological Safety Activities, Operation Teapot, Nevada Test Site, Spring, 1955.

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1. The predictability of local fallout.

Fourteen devices were detonated during Operation Teapot. In reviewing the data on predicted and measured fallout from these detonations it is found that in five cases the prediction is in substantial agreement with measured fallout, while in six cases the actual deposition of fallout was significantly at variance with the prediction. Three devices were air detonated and no fallout prediction per se was used. Chart I illustrates a case where the fallout prediction compares favorably with the fallout which actually occurred. Chart II shows a typical deviation from the prediction.[1]

It should be emphasized that these data are for gamma radiation only and represent only particulate material fallen from the cloud. They do not take into account isotopes, such as iodine, that may be in a gaseous form and may not follow the fallout pattern. We plan to study this as well as other problems related to fallout exposure during the following Operation Plumbbob as a part of our off-site operation carried out under agreement with Albuquerque Operations Office of AEC. This work also has the concurrence of the Division of Biology and Medicine of AEC.

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[1] Op. Cit.

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Data from this report also indicates that cloud tracking with planes will generally give only an indication of the direction of fallout and cannot be relied upon for precise knowledge concerning deposition on the ground.[1] Most of the time it will give an idea of the direction from the point of detonation in which the fallout will occur, but this is not always the case. For public health emergency action it is not possible to depend entirely on cloud tracking as this will not always result in a reduction in exposure.

2. Observed patterns of local fallout.

A good deal of data has been obtained in the off-site area surrounding the Nevada Test Site from which fallout patterns can be developed. Chart I through III show such patterns for individual shots. The Teapot Report contains a similar map which shows the cumulative fallout for the entire Teapot series and a tabulation of doses calculated in two ways for populated places in the area.[1]

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[1] Op. Cit.

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FALLOUT PATTERNS

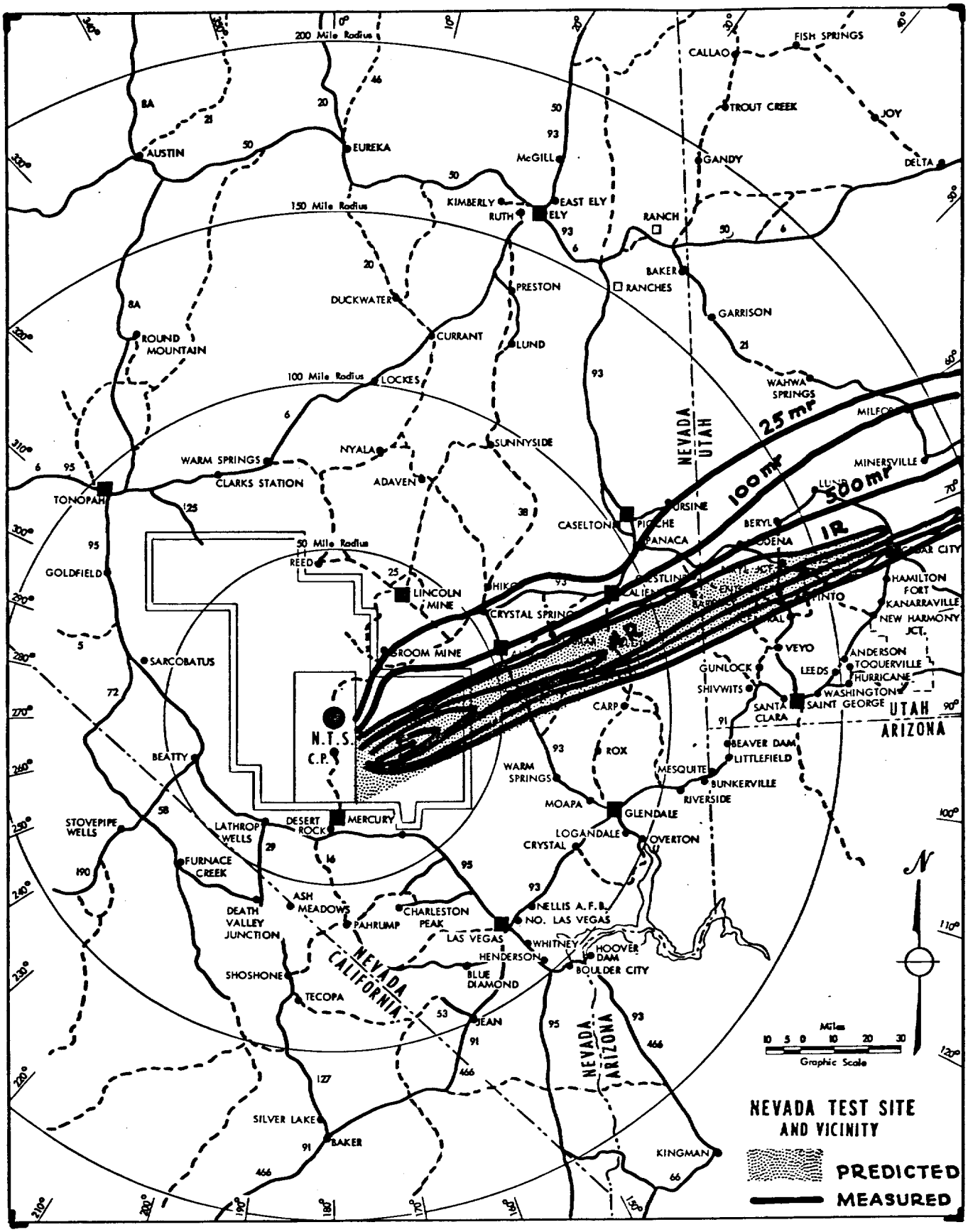

CHART 1

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FALLOUT PATTERNS

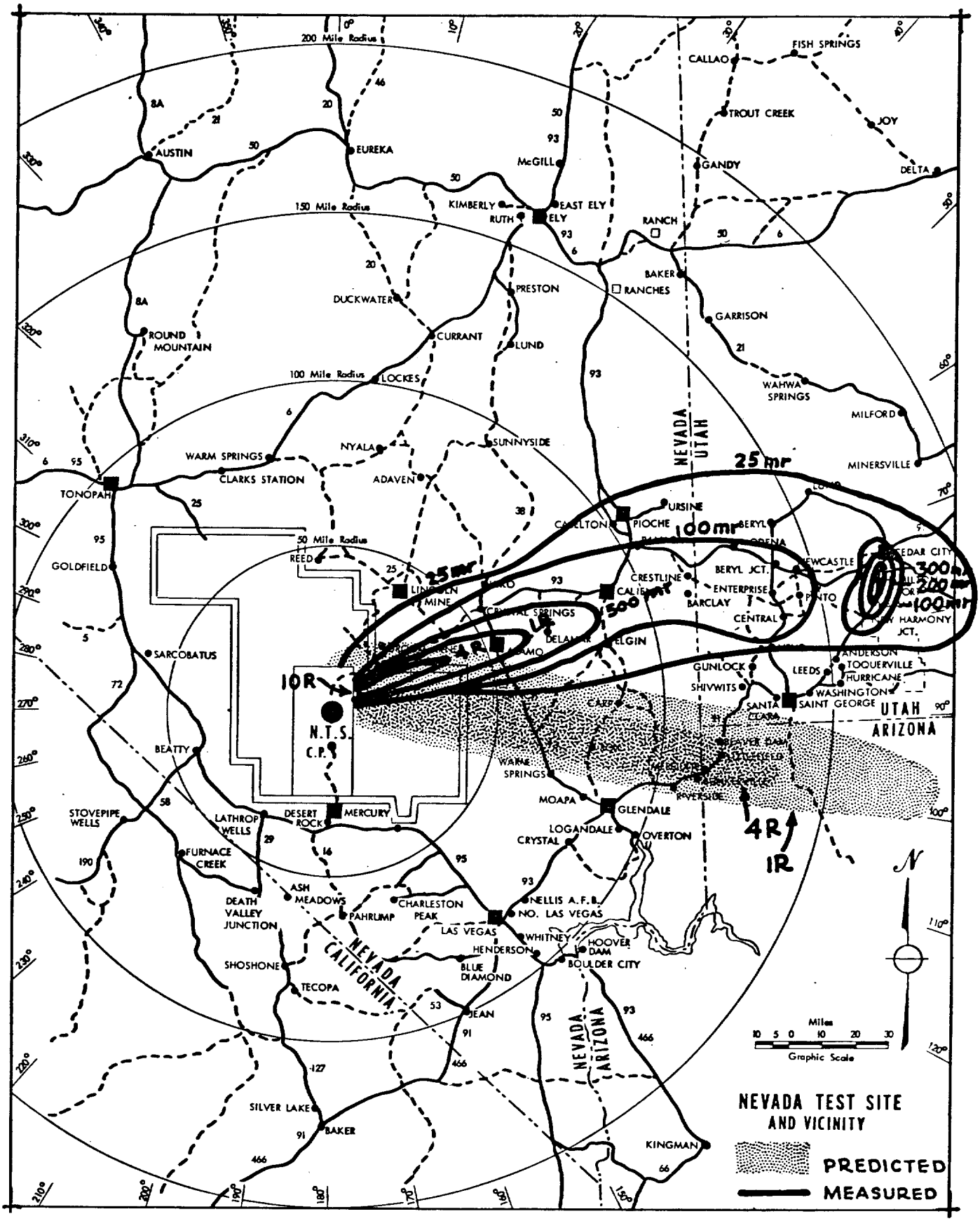

CHART 2

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FALLOUT PATTERNS

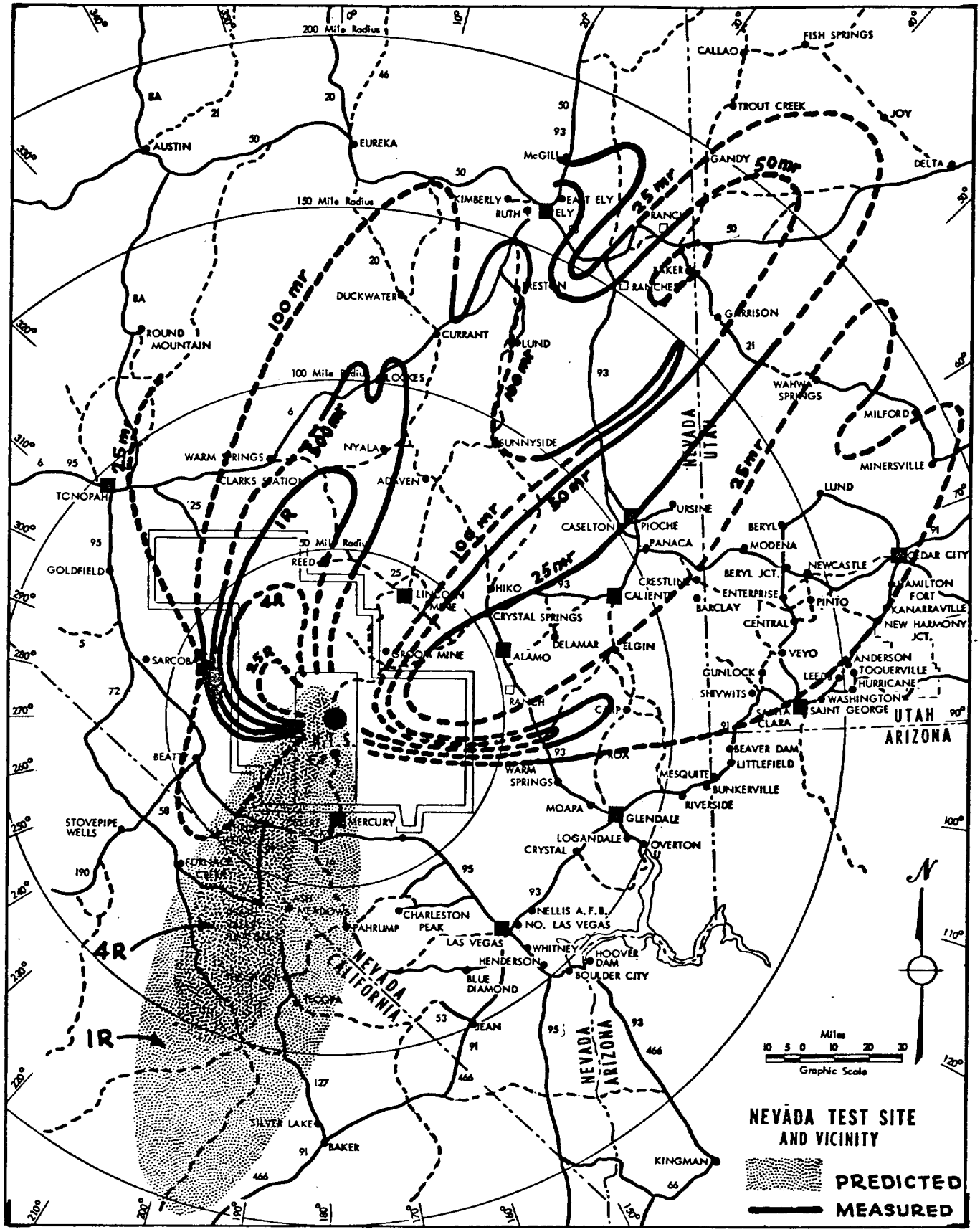

CHART 3

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To supplement this data calculated from meter readings, use was made of film badges.[1] Film badge stations consisted of the following categories: 171 worn by residents in the off-site area; 106 posted in populated areas; 152 inside and outside schools; and 126 at non-populated points in the off-site area. Data from these film badges is contained in the Teapot Report. In general they agree favorably with computed data and have the advantage of comprising a permanent record of exposures.

A comparison of the data from the film badges indicate that the dosage received by inhabitants in a particular area is less than the dose indicated for that area as measured by the same method. Approximately 94% of the dosages measured on people were within the 0 to 100 mr range while only about 57% of the film badges posted in the populated areas indicated exposures below 100 mr.[1]

The use of film badges, particularly on individuals, is being expanded during Operation Plumbbob. We are also supplementing monitoring instrument readings and film badges with recording instruments that will give us a continuous record of gamma radiation levels in a number of the populated areas.

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[1] Op. Cit.

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Data on local fallout obtained by the Public Health Service during any Pacific test series is much more limited than is the case in Nevada. During Operation Redwing the Service had personnel on the populated atolls of Utirik, Ujelang and Wotho adjacent to the Pacific Providing Grounds to maintain a record of radiation levels and initiate any necessary action to minimize exposure of the natives to radiation.[2] Data was also obtained from a weather station on Rongarik Atoll and at JTF7 Headquarters. Computed infinite doses from fallout due to Operation Redwing are as follows:

Ujelang Atoll	560 mr
Utirik Atoll	50 mr
Wotho Atoll	620 mr
Rongarik Atoll	850 mr

These figures are subject to the same qualifications as in the case of reported figures from Operation Teapot.

An attempt was made to supplement instrument readings on the populated atolls with film badge data, but, due to technical difficulties which were not overcome until near the end of the operation, these data are incomplete and inconclusive.[3]

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[2] Unpublished report "Radiation Exposures Received on Populated Atoll As a Result of Operation Redwing."

[3] Unpublished report "Report on Experimental Film Badge Study During Operation Redwing."

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C. Intermediate and Delayed Fallout.

Intermediate and delayed fallout are at concentrations and of ages to make them of little or no significance from the standpoint of acute external gamma exposure effects, but make them of relatively greater importance as internal beta emitters and with respect to the long-range biological effects. With the assistance of AEC, in 1956 and 1957, a routine system of sample collection and reporting in cooperation with State Departments of Health has been established. Our nationwide radiation surveillance network measures beta activity of particulates collected from air samples. Data from this network may be used to indicate the concentrations of radioactive materials which could expose humans to direct and indirect internal radiation hazards. Daily ambient gamma readings are also taken on a geiger counter type of survey instrument.

Two references describe the collection and measurement of radioactivity deriving from the troposphere[4, 5] The Public Health Service, for a number of years, has been developing methods which assist the States in determining environmental radiation levels and interpreting those data in terms of Public Health significance.

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[4] A Brief Review of the Public Health Service Radiation Surveillance Network, May 22, 1957.

[5] The Distribution of Radioactivity from Rain by L. R. Setter and C. P. Straub, Presented at the American Geophysical Union Meeting, April 29 - May 1, 1957, Washington, D. C.

US DOE ARCHIVES

Reference 4 summarizes the results of this operation and demonstrates the increasing amounts of fallout found in the United States from our, and foreign, nuclear tests. Reference 5 presents a more detailed study, principally in relation to rainfall, in the Cincinnati, Ohio, area.

Radioactivity in air, at any one location, is a daily variable, and cannot quantitatively be predicted from a knowledge of test schedules. For public health evaluation there appears to be no substitute for routine measurement techniques. Deposition on the ground, to a large degree, is related to rainfall. Distribution of radioactivity, geographically, is then largely dependent upon local topography and meteorology. Rainfall may contain much more activity than do the surface waters which are fed by the rainfall. The protective factors offered by the watershed may give as high as 90% removal of gross radioactivity.

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[4] Op. Cit.
[5] Op. Cit.

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Fallout from many nuclear tests is now always present in the air we breathe and the water supplies for ourselves, our animals, and our plants. Since there are many variables it is necessary to make measurements and keep records on those fact ors in the environment which directly affect man in order to make a public health evaluation of the hazards.

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VII. Local Fallout: The Mechanisms by which it can affect man and the measures he can take to minimize exposure.

B. Shelter and shielding and their effects.

By the nature of the radiation involved, it has been observed that persons can protect themselves from the acute, external effects of the beta component of fallout simply by staying under cover at the time of fallout so that none or little falls on them. Virtually direct contact with the skin is necessary to produce beta burns. We have also observed that remaining in a building will provide some protection from gamma radiation as a result of the shielding effect of the structure and the distance from the fallout afforded by being in the building.

Some data on the gamma exposure protection afforded by this means was obtained during Operation Teapot by placing film badges inside and outside of school buildings.[1] A tabulation of the results is given in the Teapot report.

The significant feature of this data is the apparent protection offered by the school buildings. The upper exposure limit is reduced by a considerable factor on a gross basis and while about 95% of the inside exposure fall within the 0 - 100 mr range, only about 79% of the outside badges are below 100 mr.

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[1] Op. Cit.

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During Operation Plumbbob the Service is going to attempt a much more complete documentation of the shielding effects of buildings. Film badges will be placed inside and outside of several different types of buildings and at several locations within the buildings. Film badge data will be supplemented insofar as possible with data from recording instruments which will give a continuous plot of time vs intensity of gamma radiation.

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C. Other immediate emergency measures that can reduce hazard.

The Public Health Service has operated under radsafe criteria in the Pacific and in Nevada which illustrates the type of emergency action which may be taken in the event of unexpectedly heavy fallout.[1, 6] These were developed jointly with JTF7 and the Nevada Test Organization respectively.

Both of these criteria recommend remaining indoors or under cover during periods of fallout to avoid direct contact with falling or settling radioactive particles. If exposed to fallout, personal decontamination is recommended including dusting and shaking off or laundering clothes and bathing with particular attention being given to washing under the arms, the groin, face and hair. Covering of food and water to prevent ingestion of fallout particles is recommended.

An emergency measure recommended in the Pacific is to stand in the lagoon immersed as far as possible in the water while continuing to wash off exposed portions of the body. This recommenda-

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[1] Op. Cit.
[6] "Radsafe Emergency Instructions for Populated Islands"

US DOE ARCHIVES

tion is based on the fact that the fallout settles from the surface and allows water to attenuate the radiations. This fact has been checked in the field by PHS personnel.

In extreme emergencies, evacuation of contaminated areas may be indicated. This procedure is practical only if the evacuation will result in lower exposures than would result by staying within a shelter and if the location and intensity of the fallout pattern is known so that persons will, in the least possible time, be moved to areas of lesser contamination rather than into an area of higher contamination.

D. Dose and dose-rate vs time.

During Redwing the PHS collected data at intervals ranging from once daily to once each hour with a gamma survey instrument at each of the atolls of concern.[2]

This data shows a phenomenon that has not, to our knowledge, been discussed to any great extent and that is the fact that, in the case of the larger weapons, the arrival of fallout may be extended over a period of several hours. Thus, although the fission products

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[2] Op. Cit.

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are decaying, this is not apparent because of the continued arrival of new fallout. Typically, the radiation intensity will build up quite rapidly to a maximum, remain at or near this maximum for a period of several hours, and then start to decrease slowly. Thus a significant amount of exposure may be received before apparent decay starts.

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VIII. Delayed Fallout

A. The relative importance of internal emitters compared with external radiation in general for the long-run fallout situation.

Elsewhere in our presentation mention has been made of the Public Health Service Surveillance programs for air, water and milk. From the data which the Service has collected, and from other published information, we are following the obvious conclusion that, especially in relation to fallout, we must develop the trends of the amounts of internal emitters in man's environment and in his food chain. Because of the masking effect of natural background, external exposure effects relatable to fallout appear to be small in long-term potential when compared to the probabilities of accumulative build-up of internal emitters.

B. Deposition on and migration in soil and transport by surface waters.

A number of Public Health Service studies are directly associated with the problem of migration and transport. Specific reference is made to the cooperative studies on high level radioactive waste performed by our staff from the Robert A. Taft Sanitary Engineering Center at Oak Ridge National Laboratory.[7]

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[7] ORNL 1684, "Radioactive Waste Disposal Research" by R. J. Morton et al, Section I - 60, Health Physics Division Semi-Annual Program Report, for period ending Jan. 31, 1954.

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In relation to the problem of transport in surface waters, background and operational studies made by the PHS at the Columbia and Savannah River systems have a direct bearing, and provide research support data.[8,9]

D. The effect of fallout on water supplies for human, agricultural, and industrial use.

The Public Health Service has studied efficiency of normal water treatment methods for the removal of radioisotopes from water supplies, and has made observations on the natural protective mechanisms.[10]

Depending of course on the exact nature of the radioactive compounds water treatment methods offer limited protection. The degree of protection is on the order of 10% to 98% removal, or a decontamination factor ranging from 1.1 to 50.

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[8] Columbia River Studies.

[9] Interim Report on the Savannah River Studies, July 1951 - July 1952. U. S. Department of HEW, Public Health Service, 1954.

[10] "Limitations of Water Treatment Methods for Removing Radioactive Contaminants" by C. P. Straub, Public Health Reports, No. 70, 897 (1955).

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The protective factors found in nature such as removal in watershed areas, are also within this range.[5] We have observed that in order to achieve removals of a much higher degree, as might prove necessary in the event of massive fallout during time of war or nuclear accident, the potential cost of effective water treatment, such as ion exchange removal, increases tremendously. The requirements in treatment materials in quantity alone is probably prohibitive. At the present time we cannot state that modern water treatment methods applicable to the general population offer substantial protection against fallout.

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[5] Op. Cit.

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12. "Measurement of Low-Level Radioactivity in Water", by L. R. Setter and A. S. Goldin, Journal American Water Works Association, Vol. 48, No. 11, Nov. 1956.

13. Unpublished Office Memo on "Measurement of Radioactivity in Water, Bottom Silts, and Biological Materials," by J. E. Flanagan, Jr., Jan. 30, 1957.

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