STATEMENT

By

TECHNICAL DIVISION
GREATER ST. LOUIS CITIZENS'
COMMITTEE FOR NUCLEAR INFORMATION
6504 Delmar Boulevard   St. Louis 30, Missouri

For

SUBCOMMITTEE ON RESEARCH, DEVELOPMENT AND RADIATION
of
JOINT ATOMIC ENERGY COMMITTEE

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I. INTRODUCTORY REMARKS AND SUMMARY OF TESTIMONY

To the general public, the most important question about
fallout from nuclear tests is: "What is the risk of medical
harm to the population as a result of fallout; if there is a
risk, what can be done to reduce it?" Since its inception,
the United States program of nuclear tests has included a
considerable effort to determine the deposition of fallout
outside the actual test area, to estimate the possible medical
hazard of such fallout to persons exposed to it, and to warn
of needed countermeasures when the occasion arises. Contributing
to this effort has been the work of the AEC, the agency
directly responsible for nuclear test operations, the U. S.
Public Health Service, and the hearings conducted by the
Congressional Joint Committee on Atomic Energy.

Two separate aspects of the problem need to be considered:
(a) The medical risks to the total population resulting from
the widespread dissemination of radioactivity from tests which
occur anywhere in the world. (b) The medical risks to local
populations, resulting from relatively short-range fallout
which spreads rapidly from the test site in Nevada to surround-
ing communities, and sometimes - depending on weather condi-
tions - to distant areas in the continental United States. The
first of these problems has been given extensive consideration
recently; the St. Louis Citizens' Committee for Nuclear Infor-
mation (CNI) has previously submitted extensive testimony rel-
evant to it.

In the present testimony we are concerned with the second part of the problem: What medical risk may be faced by local populations as a result of short-range fallout from the Nevada Test Site? The Technical Division of CNI has made a detailed analysis of this problem which may be summarized as follows:

1) The AEC has maintained a system for monitoring fall-out radioactivity in regions surrounding the Nevada Test Site, in order to assess the possible hazards to local populations and to warn of needed precautionary measures. Many of the radioactivity readings obtained during nuclear tests, conclusions regarding possible medical hazards, and recommended countermeasures have been presented by the AEC in reports and in testimony before this Committee. The general conclusion put forward in these AEC reports has been that the test program has been carried out without any discernible threat to the safety of local populations. In some instances local groups were advised to stay indoors for a short period, or to evacuate, briefly, a particular location in which excessive exposure was expected.

2) In contrast our analysis of the same monitoring data published by the AEC shows that as a result of nuclear tests at the Nevada Test Site in the period 1951-62, a number of local populations especially in Nevada, Utah and Idaho, and probably other communities scattered throughout the continental United States have been exposed to fallout so intense as to represent a medically unacceptable hazard to children who may drink fresh locally-produced milk.

3) The reason for the serious discrepancy between AEC conclusions and our own conclusions regarding the safety of the Nevada test program is the following:

Nearly all monitoring data reported by the AEC represent radioactivity measurements of either the gamma-ray intensity emanating from the ground, the total beta-radioactivity deposited on a gummed film placed on or near the ground, or of total beta activity in the air. There are established safety standards regarding exposure to the body from a given level of radioactivity which has its source outside the body. These standards for external exposure have been used, by the AEC, to evaluate environmental radioactivity measurements during nuclear tests. In most cases, the measurements in the regions neighboring the test site did not exceed this safety limit. The AEC therefore concluded that there was no hazard to the nearby populations. In the few instances where the gamma and beta measurements indicated that this safety level for external exposure would be exceeded, protective measures (remaining indoors, or evacuation) were recommended.

The foregoing AEC interpretation of gamma and beta radiation measurements is, however, valid only if the fallout which gives rise to this radioactivity does not enter into the food chain. If fallout radioisotopes do enter the food chain and find their way into the body, certain isotopes become highly concentrated in a particular part of the body and expose it to very intense radiation. Safety standards for external exposure are then no longer applicable. Iodine 131 is a par-

ticular problem in this regard for it becomes quickly concentrated in the thyroid gland when taken in with the food.

Thus if a gamma radiation monitor in a pasture outside the Nevada Test Site shows a reading of .087 r/hr at 12 hours following the time of a nuclear test, measured at three feet above ground level, this indicates the apparently maximum safe level, since the permissible standard for continuous exposure from a source external to the body is 3.9 r/year (effective biological dose), which is equivalent to a dose rate of .087 r/hr at 12 hours following a test. However, if a milk cow feeds on this pasture and its milk is freshly consumed by a small child, this conclusion becomes invalid. Under these circumstances it can be shown that this same gamma reading (i.e. .087 r/hr) probably reflects a concentration of iodine 131 in the grass, which after passing into the cow's milk and being consumed by the child may deliver to the child's thyroid gland a radiation dose of 175 to 1200 rads. This dosage exceeds even the safety standards for radiation workers (30 rads to the thyroid per year) by a factor of 5 to 40 and is so high as to represent a serious potential cause of thyroid cancer.

Thus the U.S. conclusions regarding safety in the Nevada Test Site region become invalid if it can be shown that the readings on which they are based were taken in the regions in which milk cows graze and produce milk that is freshly consumed by children locally. Our study of a number of regions around the Nevada Test Site shows that in many cases fallout sufficiently intense to contain such excessive amounts of iodine 131

has probably occurred in areas which produce milk that is
freshly consumed by significant numbers of children. There-
fore the published values of gamma and beta radiation indicate,
in many instances, not that the region is totally safe for its
inhabitants, but that local children have been subjected to
grossly excessive radiation doses to their thyroid glands.

Washington county, Utah with a live birth rate of more
than two hundred can serve as an example of the problem con-
fronting communities around the Nevada Test Site. At least
seven times since 1952, Washington county children received thy-
roid doses in the 5 to 100 rad range or higher. Milk for
these children seems to come almost entirely from local
dairying. Even in the largest town, St. George (pop. 5,000),
one dairy collects milk only in Washington county and another
from cows in three surrounding counties. Hence, farm children
drinking milk from the family cow were not alone among children
exposed in the county. On May 19, 1953, in the whole of
Washington county, gamma readings from shot "Harry" show that
the minimum dose a child probably received would be 50 rads.
St. George received 100 to 700 rad possible thyroid dose and
Hurricane showed 150 to _0 rad values. Later, on August 31,
1957, shot "Smoky" of the Plumbob series delivered an esti-
mated 10 to 67 rad thyroid dose over an 8000 square mile area
outside the Nevada Test Site, including Washington county.
The local fallout pattern from that shot spread significant
doses as far as 700 miles north to Rock Springs, Wyoming.

It might be added that the Atomic Energy Commission issues licenses for the handling of iodine 131 concentrations higher than .02 microcuries per liter. Our estimates show that dozens of times the milk in these areas could contain more than .05 microcuries per liter. Strictly speaking, the farmers and dairies should have had an AEC license to handle the milk at all.

4) The biological effects of radiation exposure of the thyroid, at the levels expected in the region of the Nevada Test Site, are readily deduced from the available literature. There is general scientific agreement that radiation in sufficiently large doses can cause thyroid cancer. It is also agreed, as stated in the Federal Radiation Council Report No. 2 (September 1961), that "the child's thyroid is more sensitive to the carcinogenic effects of radiation than the adult thyroid. This conclusion is based upon several studies in recent years of the occurrence of thyroid carcinoma in children who had previously received therapeutic X-irradiation in the neck region for enlarged thymus or for other benign head and neck conditions. The incidence of thyroid carcinoma in these children was significantly higher than in control groups who had not been previously irradiated. In these studies cancer of the thyroid was observed in children after exposures as low as approximately 100 rem."

Thus, the possible thyroid radiation exposures of children near the Nevada Test Site is clearly in the range considered

carcinogenic by the Federal Radiation Council. On the assumption that the induction of cancer is proportional to radiation exposure, an estimate of risk can be made. Beach and Dolphin, of the United Kingdom Atomic Energy Authority, considering several sources of data, calculated that, on the average, 35 cases of thyroid cancer may be expected per million persons exposed to one rad of thyroid radiation. In terms relevant to the present testimony, 1 in 286 children exposed to 100 rad thyroid radiation may develop thyroid cancer. By any standard, this is an unacceptable risk

Estimates of radiation damage are difficult, not only because of the uncertainties of some of the assumptions, but also because damage does not become evident for many years after the exposure has taken place. The average latent period between radiation and cancer of the thyroid approximates 10 years; in some instances, the latent period may extend to 20 years. If the thyroid radiation exposures near the Nevada Test Site are as high as suggested in this testimony, careful medical follow-up of exposed populations might yield evidence of damage by this time

5) A survey of the available gamma and beta radiation measurements of fallout resulting from 31 of the total of 99 tests conducted in Nevada in the period 1952-58 shows that conditions which (under the circumstances stated above) lead to hazardous thyroid exposures in children have occurred not only in areas neighboring the Nevada Test Site, but also in

local regions scattered across the continent as far as Troy, New York. This comes about as a result of weather conditions at the time of a particular explosion, which may quickly carry fallout at high altitudes for many miles, and then precipitate it to the ground where an intense thunderstorm occurs. Local fallout deposition which could have resulted in thyroid exposures to children in the range of 5 to 40 rads have, for example, occurred in Troy, New York on April 26, 1953 and in Roswell, New Mexico on April 25, 1953. Salt Lake City values were 3 to 18 rads for fallout on May 7, 1952, and 2 to 12 rads for fallout on March 24, 1953.

6) This hazard has arisen not only from nuclear tests in the atmosphere and at the earth's surface, but also as a result of certain <u>underground</u> nuclear tests. Venting (production of radioactive clouds capable of producing fallout) has been reported for at least seven underground nuclear tests: Shot ESS of Operation Teapot, September 15, 1961; Project Gnome shot, December 10, 1961; the Des Moines shot, June 13, 1962; Project Sedan, July 6, 1962; and shots on March 5, 1962, April 14, 1962, and May 19, 1962. Although data for these shots are relatively limited, we calculate that, for example, fallout from the underground Gnome shot delivered sufficient fallout to the vicinity of Carlsbad, New Mexico to cause thyroid levels of from 7 to 55 rads in children, under the circumstances outlined above.

7) If the gamma and beta radiation measurements taken during Nevada tests had been correctly interpreted at the time that they were made (i.e. taking into account the resultant exposure to children's thyroids where the food chain conditions led to iodine 131 intake), simple preventive measures could have been taken to avoid exposure. This would require only that inhabitants of the region be warned to avoid the drinking of fresh milk produced locally. Fluid milk supplies from other regions, or powdered milk, could have been readily substituted, thereby preventing the ingestion of excessive iodine 131 from local milk. We know of no instance in which such a warning was issued. until the summer of 1962, when high iodine 131 levels observed in commercial milk supplied in Utah led state health officials to divert current milk from the market.

8) Correct interpretation of gamma and beta radiation monitoring measurements should have been possible by 1954 on the basis of then-available scientific theory. Thus, it was known at that time that (a) iodine 131 comprises a specific fraction of the total fission product, which can be estimated from overall measurements of gamma and beta radiation and the age of fallout deposit; (b) iodine 131, along with other fallout products, is deposited on pasture grass and enters the food chain; (c) iodine 131 in food becomes concentrated in the thyroid, thereby increasing its biologically effective dosage to the body. After 1957 there was not only a theoretical basis for this interpretation, but also a detailed practical illustration of its importance. In that year a

British nuclear reactor at Windscale accidently emitted a very considerable amount of radioactive debris. Detailed monitoring measurements showed that pasture land contaminated by this fallout produced milk so heavily contaminated with iodine 131 as to necessitate that it be dumped. The scientific studies of the Windscale disaster provide valuable data which can be used to develop the proper interpretation of the monitoring measurements in the region of the Nevada Test Site. Although the important differences between the hazard of external radiation from fallout, and the internal hazard, especially to the thyroid, was recognized by at least one AEC official in 1959 (see Gordon Dunning testimony to Subcommittee on Research, Development and Radiation, Hearings, 1959, p. 445) monitoring procedures, and interpretation of results were not altered to bring them in line with this concept. Thus, the inadequate interpretative procedures which have until now obscured the true hazard resulting from short-range fallout from nuclear tests in Nevada, could have been corrected some years ago.

9) Correction of the described inadequacy of monitoring procedures would affect not only estimates of hazard from atmospheric and underground nuclear tests, but also hazards possible from accidents affecting nuclear reactors, which also produce iodine 131 debris.

On the basis of the foregoing considerations, the analysis of the hazard from fallout in the region of the Nevada Test

Site prepared by the St. Louis Committee for Nuclear Information reaches the following conclusions:

1) Analysis of the available evidence shows that children residing in the states bordering the Nevada Test Site have, as a result of fallout from nuclear tests at that site, probably been exposed to medically significant radiation.

2) These exposures were avoidable, for on the basis of radiation monitoring carried out by the AEC during the test programs, the probability of exposure should have been evident in time to warn the population to take simple precautionary steps.

3) Monitoring procedures in the Nevada Test Site regions have been inadequate in that they do not take into account the importance of internal exposure to radioactivity entering the body in fallout-contaminated food. Direct and prompt measurement of iodine 131 in local milk, which is the most effective method of estimating the hazard from this isotope have not been done, or, if done, have not been reported. Moreover, indirect but nevertheless useful estimates of the iodine 131 hazard, which can be determined from the available gross gamma and beta radioactivity measurements have not been made heretofore.

4) Past assurances of the safety to nearby populations of the Nevada test programs are not substantiated by the present analysis of available data. Assurances that "the hazard has been successfully confined to the controlled areas

of the Test Site" are not justified in the absence of direct
measurements of radioactivity levels in local milk. Even the
inadequate indirect measurements that have been carried out,
if properly interpreted, should have alerted the responsible
agencies to the serious potential health hazards during test
programs and to the necessity of warning the population to
take simple, readily available protective measures.

5) These hazards are not restricted to atmospheric tests
alone. Available data show that following at least 7 under-
ground tests, local fallout contamination comparable to that
produced by atmospheric tests occurred.

6) In view of the foregoing conclusions we recommend,
urgently, a thorough review of present fallout monitoring
procedures, with a view to rectifying the present inadequacies
with respect to data, interpretation, and public information
regarding precautionary measures. In view of the probable
high radiation exposures to the population in the Nevada Test
Site region we recommend a careful medical follow-up study
of exposed individuals, in order to facilitate detection and
treatment of possible diseases.

II. A REPORT ON THE IODINE 131 HAZARD FROM SHORT-RANGE

FALLOUT PRODUCED BY NUCLEAR TESTS AT THE NEVADA TEST

SITE

1) The problem

This report is an inquiry into the hazard resulting from
exposure of local populations, especially in the vicinity of the
Nevada Test Site to iodine 131 in fallout produced by nuclear
explosions at that site.

At the hearings of the Joint Congressional Committee on
Atomic Energy held in 1957, Dr. Lyle Alexander summarized
the iodine 131 hazard briefly: "For a period of days following
a heavy deposition of fresh fallout, iodine 131, which has a
half life of 8 days, may be of importance in direct contamina-
tion of vegatation. Radioiodine is selectively concentrated
in the thyroid gland, where excessive accumulations cause
cancer and cell destruction. Injury to the gland may not
be detected until long after the iodine has decayed."[1]

The Federal Radiation Council, in its Report #4, states
that "In the special case where nearly all of the annual intake
(of iodine 131) could come from exposure to abnormally high
concentrations in a local area, resulting from a single
nuclear explosion of low yield, the Council recognized that
some small number of individual infants could conceivably
receive doses 10 to 30 times the average for the area as a
whole." The highest average dose to infant thyroids due
primarily to one high excursion of levels in 1962 was 620
millirems in Salt Lake City, where most of the dose did

result from a single brief series of test explosions.[2]
The highest individual dose, therefore, could have been
30 times the average, or 18.6 rems.

Thus, it has been recognized that iodine 131 represents
a potentially important hazard from fallout. Until recently,
considerations of this problem, with few exceptions, have
been limited to iodine 131 exposures expected in the popula-
tion as a whole during periods of active testing. This
problem has been discussed in detail before the JCAE, and
the St. Louis Committee for Nuclear Information has reported
on it.[3A] It has been recognized that rapid measurements of
iodine 131 in milk provide a useful index of the radiation
exposure to the thyroid expected in a child consuming the
milk. While this type of information is therefore important
in estimating the iodine 131 hazard from fallout it has cer-
tain limitations. Nearly all available measurements of
iodine 131 in milk are based on large commercial supplies.
These represent pooled milk from many widely scattered farms.
Such measurements are, of course, valuable in estimating the
iodine 131 intake of children who drink commercial milk
of this type. However, the pooling process conceals variations
in iodine 131 levels among separate regions and it is im-
possible to determine how much iodine 131 would be taken in
by a child who consumes fresh milk directly from a cow or
herd stationed in a particular local area. Nevertheless,
the latter is the situation which governs milk consumption

of many rural children. Since much of the region surrounding the Nevada Test Site is occupied by farms and rather small towns, in which this type of local milk consumption must prevail, it becomes necessary to know the iodine 131 content of numerous separate small farm-size milk supplies in order to determine the iodine 131 intake of children living in this region.

Unfortunately appropriate measurements of iodine 131 in local milk supplies do not appear to have been made. For this reason direct estimates of the hazard to the thyroid are not possible, as they are in the case of many large-scale populations which consume commercial milk supplies. Iodine 131 measurements of commercial milk supplies for a number of cities have been available since 1957.

Because of the lack of such direct information on iodine 131 levels of milk consumed by children in the region of the Nevada Test Site, it becomes necessary to develop a method for estimating these values from other types of fallout measurements.

In what follows, we consider how this can be done.

2) Indirect estimation of iodine 131 levels from
overall measurements of gamma and beta radiation

When nuclear fission occurs, a wide range of atomic products result. The physical processes which result in the appearance of the different products of nuclear fission have been studied extensively. From these studies,

it is known that particular radioisotopes, such as iodine 131,
represent a relatively constant proportion of the total radio-
active debris. Hence, if a measurement of the <u>total</u> amount of
fallout is obtained it is possible to calculate the amount of
iodine 131 produced. From this value one can estimate the
amount of iodine 131 present in fallout by determining the
"age" of the fallout, i.e. the time between its production in
the nuclear explosion and its measurement, for like all radio-
isotopes iodine 131 decays with time. Thus, if one makes a
measurement of the total gamma or beta radioactivity emitted
by a sample of fallout, and can also determine its "age," it
is possible to estimate the amount of iodine 131 present. The
relevant calculations are presented in detail in the Appendix.
During this interval some "fractionation" may possibly occur,
i.e., as the fallout drifts along, some isotopes may become
deposited out sooner than others. Not much is known about
this process. In keeping with general practice in this field
(see for example, Dunning, Hearings, Radiation Subcommittee,
1959. Biological and Environmental Effects of Nuclear War,
p. 443), the possible effects of fractionation are not
considered in our calculations.

Once an estimate of iodine   131 on the ground
is available, it is possible quite readily to calculate how
much of it will go into milk, and how much of the radioiodine
in the milk will become concentrated in the thyroid of a child
drinking one quart of milk per day (the standard usually used
in fallout calculation).

This can be accomplished from a consideration of known cases of fallout and transmission from contamination on grass to milk and resultant thyroid iodine levels. Lapp[5] has made such a calculation based on the fallout incident at the Windscale pile No, 1, an experimental nuclear reactor, which caused the release of 20,000 curies of iodine 131 to the atmosphere. The iodine fell on farms in the area and then appeared in cows' milk in amounts as high as 100,000 micromicrocuries per liter. Though infants did not drink the milk because it was removed from the market, the thyroid radiation dose that would result from such concentrations can be calculated on the basis of standard dosimetry procedures. The combined calculation indicates that $1 c/M^2$ deposition of iodine 131 results in a dose of 5 rads to an infant thyroid gland. This is the basis for the lower of our two estimates. (See Appendix for details)

It should be noted that Lapp was not the first to make use of the Windscale experience. Gordon Dunning estimated in 1959 the thyroid dose due to raioiodine in fallout. His estimate indicates, "Based on Windscale experience, $1 \mu c I^{131}/M^2 \rightarrow 0.1 \mu c I^{131}/$liter of milk. For one liter of this milk $\rightarrow$ 2 rad dose to infant's thyroid. For continuous consumption of milk from cows grazing on pasture until I^{131} activity essentially zero $\rightarrow$ 22-44 rad dose."[6] His calculation was for a wartime situation, but an atmospheric nuclear explosion creates and deposits radioactive fallout irrespective of the use to which it is put.

Dunning's estimate is somewhat higher than that derived in this paper from the Windscale evidence because he assumed that 100 per cent of deposited iodine 131 is retained on edible herbage, whereas we assume only 40 per cent. Higher yet is a figure based on experiments by R. J. Garner, who observed the transfer of iodine 131 from the diet of cows to their milk.[7] Based on Garner's data $1 \cdot cI^{131}/M^2$ yields a 36 rad dose to the infant thyroid, for continuous ingestion.

Thus empirical evidence indicates a range for the infant thyroid dose due to a given deposition of iodine 131 on an area where milk cows graze. Using the steps described earlier, it is possible to estimate the thyroid dose on the basis of external beta and gamma intensities. For example, a gamma intensity of 30 milliroentgens/hour at Belmont, Nevada, 8 hours after an explosion on 28 May 1957 indicates an iodine deposition of 650 $\mu\mu c/cm^2$ and a possible resultant peak level in milk from cows eating grass in the area, of from 260,000 to 1,040,000 $\mu\mu c$/liter of milk. The dose to an infant's thyroid from continued ingestion of this milk would probably be between 32 and 214 rads. Or, using beta readings, the average beta count at Salt Lake City on May 7, 1952, for example, was 23,000,000 disintegrations per minute per square foot $(d/m/ft^2)$. This would be expected to lead to infant thyroid doses of from 3 to 18 rads.

3) Estimates of Theoretically Possible Thyroid Doses

Due to Short-Range Fallout From the Nevada Test Site

As shown above it is possible to calculate, from local
measurements of gamma and beta radiation, what radiation
exposure to a child's thyroid might theoretically result from
a given deposit of fallout. Since the AEC has reported
numerous measurements of gamma and beta radiation, together
with the times of measurement, and their relation to a
particular nuclear explosion (the time of which is also given),
these data can be converted to estimates of possible iodine
131 exposures to the thyroid according to the procedures
outlined above, and given in detail in the Appendix. Such
calculations have been made for 189 different readings at
various locations following 31 different nuclear test shots
conducted at the Nevada Test Site during the period 1952-
1958. The overall results are presented in Tables I-V.
In each case, two estimates of the possible thyroid dose have
been calculated, using the two different observations (Wind-
scale and Garner) described above. The lower of the two
estimates yields thyroid dosages which range from 0.6 rad
to 555 rads. The higher of the two estimates yields thyroid
dosages which range from 4 rads to 3760^{I} rads. According to
the higher estimate, of the separate locations, 50^{II} received
sufficient fallout to result in a possible dose of 100 rads
or more to the thyroid. In 15 cases even the lower estimate
yielded a thyroid dose over 100 rads. It is evident from this
summary that the Nevada tests have produced instances of

Table I

Some Estimated Infant Thyroid Doses for 1953.
(Operation Upshot-Knothole).[5,9]

Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Density $\mu\mu c/cm^2$	I-131 in Fresh Milk $\mu\mu c/l$ based on: Windscale	Garner	Dose to Infant Thyroid - Rads Windscale	Garner
SHOT ANNIE - 0520 PST - 17 MARCH 1953 - 16.2 Kt. - 300' - TOWER							
St. George, Utah	20	8	504	202,000	806,000	25	166
Rockville, Utah	24	12	970	390,000	1,550,000	48	320
US 93, 30 mi N of Alamo, Nevada	110	7-1/3	2,380	450,000	3,800,000	119	785
US 91, 10 mi N of St. George, Utah	110	5	1,600	640,000	2,550,000	80	525
Nov 55, 22 mi N of US 91	260	2-2/3	1,800	730,000	2,900,000	91	600
SHOT NANCY - 0510 PST - 24 MARCH 1953 - 24.4 Kt. - 300' TOWER							
1 mi NW Crystal Springs, Nevada	140	5-1/2	2,050	815,000	3,250,000	103	670
Hwy 93, 59 mi S of Ely, Nevada	45	7-1/4	970	389,000	1,550,000	48	320
Adaven, Nevada	11	8	277	111,000	444,000	14	91
8 mi NW of Lincoln Mine, Nev	85	9	2,460	990,000	3,940,000	123	814
32 mi SW of Lincoln Mine, Nev	32	58	7,250	2,900,000	13,100,000	363	2,400
Sunnyside, Nevada	17	10-1/4	557	222,000	890,000	28	183
St. George, Utah	.3	12	12	4,900	19,400	.6	4
SHOT BADGER - 0435 PST - 18 APRIL 1953 - 23.0 Kt. - 300' - TOWER							
17 mi SW of Glendale Jct. on Hwy 91	38	31-2/3	4,480	1,790,000	7,150,000	224	1,480
Jct Hwy US 91 and Nev 40	35	28	3,680	1,470,000	5,890,000	184	1,210
14.5 mi W of Jct Nev 12 & 40 on 40	38	27-1/3	3,850	1,540,000	6,150,000	192	1,270

Table I (Cont'd)

Hot Spot Location	γ Rate mr/hr	Time of Reading H + hrs	I-131 Density μμc/cm²	I-131 in Fresh Milk μμc/l based on: Windscale	Garner	Dose to Infant Thyroid - Rads Windscale	Garner
SHOT SIMON - 0430 - 25 APRIL 1953 - 42.7 Kt. - 300' - TOWER							
Mesquite, Nevada	30	10	485	394,000	1,730,000	49	325
Bunkerville, Nevada	100	10-1/3	3,280	1,310,000	5,250,000	164	1,080
24 mi W of Mesquite on US 91	110	27-1/2	11,100	4,440,000	17,800,000	555	3,760
20 mi N of Glendale Jct on US 93	80	29	8,840	3,500,000	14,100,000	440	2,910
Alamo, Nevada	1.8	10-2/3	61	24,500	98,000	3	20
Groom Mine, Nevada	0.2	13	8.5	3,500	14,100	.4	3
Riverside Cabins	300	10	984	394,000	1,575,000	49	325
St. George, Utah	.5	12	20.2	8,100	32,400	1	6
Santa Clara, Utah	5.0	32	600	240,000	960,000	30	200
SHOT HARRY - 0505 PDT - 19 MAY 1953 - 32.4 Kt. - 300' - TOWER							
Hwy 93, 32 mi N of Glendale, Nevada	18	33	2,270	910,000	3,630,000	113	750
St. George, Utah	16	36	2,220	890,000	3,560,000	111	735
Washington, Utah	28	13	1,240	495,000	1,980,000	62	409
..., Utah	42	8	1,060	420,000	1,690,000	53	350
...erne, Utah	80	11-1/2	2,940	1,170,000	4,700,000	147	970
...b, Utah	15	28-2/3	1,570	630,000	2,520,000	79	525
Rockville, Utah	80	9	2,320	930,000	3,720,000	116	765
Orderville, Utah	14	32	1,685	675,000	2,700,000	84	555
Cedar City, Utah	18	12	730	292,000	1,170,000	36	240
Veyo, Utah	20	28-1/2	2,100	840,000	3,360,000	105	695

Table II

Some Estimated Infant Thyroid Dose for 1955 (Operation Teapot).[1,10]

Hot Spot Location	γ Rate mr/hr	Time of Reading H + hrs	I-131 Density μμc/cm²	I-131 in Fresh Milk μμc/l based on: Windscale	Garner	Dose to Infant Thyroid - Rads Windscale	Garner
SHOT WASP - 18 FEB. 1955 - 1.2 Kt. - 726' - AIR DROP							
Nev 85, 28 mi S of Pahrump	5.5	3.6	62	25,100	37,600	3	21
SHOT MOTH - 22 FEB. 1955 - 2.4 Kt. - 300' - TOWER							
Dry Lake, Nevada	6.0	6.3	109	43,500	174,000	5	36
US 93-91, 1 mi SW Dry Lake	29	6.4	525	210.000	840,000	26	173
SHOT TESLA - 1 MARCH 1955 - 6.8 Kt. - 300' - TOWER							
Santa Clara, Utah	6.0	11.5	220	880,000	3,500,000	11	73
St George, Utah	4.0	10.2	131	525,000	2,100,000	7	43
Gunlock, Utah	0.3	10.9	11	4,400	17,500	.6	4
Ash Springs, Nevada	4.5	9.2	130	52,000	209,000	7	43
20 mi S of Alamo on US 93	55	5.2	800	320,000	1,280,000	40	264
SHOT TURK - 7 MARCH 1955 - 43.0 Kt. - 500'- TOWER							
Current, Nevada	.98	29.4	108	43,000	173,000	5	36
Ely, Nevada	1.00	28.4	105	42,000	168,000	5	35
Warm Springs, Nevada	1.50	34.8	203	81,000	324,000	10	67
7 mi S Lockee on US 6	3.00	31.0	405	162,000	648,000	20	134
SHOT HORNET - 12 MARCH 1955 - 300' - TOWER							
Glendale, Nevada	14.0	7.7	353	141,000	565,000	18	116
Moapa, Nevada	10.0	6.5	216	86,000	346,000	11	71
Warm Springs Ranch	7.0	5.2	102	40,600	162,000	5	34
SHOT BEE - 22 MARCH 1955 - 8.1 Kt. - 500' - TOWER							
Las Vegas, Nevada	9.0	5.5	163	65,000	260,000	8	54
North Las Vegas, Nev	13.0	5.1	189	75,000	300,000	9	62
US 93-95, 3 mi S of Henderson	18	5.1	261	104,000	418,000	13	86

Table II (Cont'd.)

Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Density c/cm²	I-131 in Fresh Milk μμc/l based on:		Dose to Infant Thyroid - Rads	
				Windscale	Garner	Wind-scale	Garner
SHOT ESS – 23 MARCH 1955 – SUBSURFACE							
Lake Mead Base, Nev	1.5	4.0	16.8	6,700	27,000	.8	6
Glendale, Nevada	1.5	7.2	32.4	13,000	52,000	2	11
US 93, 38 mi S of Alamo	6.3	3.0	50.4	20,000	81,000	3	17
22 mi N Indian Springs, Nevada	140.0	5.3	2,030	312,000	3,250,000	100	670
SHOT APPLE I – 29 MARCH 1955 – 15.5 Kt. – 500' – TOWER							
Alamo, Nevada	160.0	2.8	1,280	512,000	2,050,000	64	420
Panaca, Nevada	2.5	5.9	45	18,100	72,000	2	15
Caliente, Nevada	9.0	4.9	131	52,000	209,000	7	43
Enterprise, Utah	9.5	6.8	206	82,000	328,000	10	68
Kanarraville, Utah	10.0	5.7	181	72,000	290,000	9	60
Newcastle, Utah	10.0	6.7	216	86,000	346,000	11	71
Hamilton Fort, Utah	6.0	5.7	109	43,500	174,000	5	36
SHOT MET – 9 APRIL 1955 – 300' – TOWER							
Buckhorn Ranch, Nev	140	2.6	1,120	450,000	1,800,000	56	370
Elgin, Nevada	200	5.1	2,900	1,160,000	4,650,000	145	960
Beryl, Utah	6.0	6.6	130	52,000	207,000	6	43
Zane, Utah	16.0	6.8	346	138,000	550,000	17	114
Lund, Utah	9.0	7.3	194	78,000	311,000	10	64
Beaver, Utah	3.5	25.3	315	126,000	500,000	16	104
Minersville, Utah	2.5	22.1	208	83,000	332,000	10	68

Table II (Cont'd)

Location	Dose Rate mr/hr	Time of Readings H + hrs	I-131 Dens uc/cm²	I-131 in Fresh Milk uc/l Windscale	Garner	Dose to Infant Thyroid - Rads Ind-scale	Garner
WASP II - 5 MAY 1955 - 30.0 Kt. - 500' TOWER							
McGill, Nevada	18.0	4.2	202	81,000	325,000	10	63
Ursine, Nevada	30.0	5.8	544	217,000	870,000	27	180
Pollini Ranch, Nevada	15.0	5.0	189	75,000	302,000	9	62
Reed, Nevada	110.0	6.8	2,340	950,000	3,800,000	119	785
Locker Ranch, Nevada	38.0	5.3	551	220,000	8,800,000	28	182
Currant, Nevada	8.0	6.5	143	69,000	276,000	9	57
...center, Nevada	16.0	7.3	346	138,000	550,000	17	114
ZUCCHINI - 15 MAY 1955 - 500' - TOWER							
...lage Ranch,	50.0	3.4	400	160,000	640,000	20	132
Nyala, Nevada	65.0	3.9	728	290,000	1,160,000	36	240
Crystal, Nevada	11.0	3.5	123	49,000	197,000	6	41
Logandale, Nevada	20.0	5.3	290	116,000	464,000	14	96
St. George, Utah	3.0	8.6	87	35,000	139,000	4	29
Cedar City, Utah	4.8	7.0	104	41,500	166,000	5	34
Washington, Utah	3.9	9.6	128	51,500	205,000	6	42
...owan, Utah	5.5	11.7	223	89,000	356,000	11	74
...onah, Utah	4.6	11.8	186	75,000	290,000	9	62
Kanarraville, Utah	2.8	8.7	81	32,000	130,000	4	27

Table III

Dose Estimate : Infant Thyroid Dose for 1957.
(Operation Plumbbob, NTS Data)

Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Intensity μμc/cm²	I-131 in Fresh Milk c/l based on:		Dose to Infant Thyroid - Rads Wind-Garner scale
				nationale	Garner	
SHOT BOLTZMAN - 28 MAY 1957 - 11.5 Kt. - 500' - TOWER						
Belmont, Nevada	30	7.2	650	260,000	1,040,000	32	214
Currant, Nevada	1.3	14.5	63	25,000	100,000	3	21
Fallon, Nevada	1.6	40	157	62,000	250,000	8	51
Millett, Nevada	2.5	35.7	345	134,000	535,000	17	110
Pardon s Ranch, Nev	22.0	10.7	718	287,000	1,150,000	36	236
Reveille Mill, Nev	80.0	10.7	2,620	1,050,000	4,200,000	131	865
Round Mt., Nevada	6.0	9.9	197	29,000	315,000	10	65
Stone Cabin Ranch	14	8.7	352	141,000	565,000	17	116
Stone House Ranch	45	9.7	1,300	520,000	2,090,000	65	430
SHOT WILSON - 18 JUNE 1957 - 10 3 Kt. - 500' - BALLOON						
Lockty, Nevada	2.0	7.2	43	17,300	69,000	2	14
SHOT PRISCILLA - 24 JUNE 1957 - 36.6 Kt. - 700' - BALLOON						
Buckhorn Ranch, Nev	1 2	11	44	17,600	705,000	2	15
Caro, Nevada	4.5	10 7	148	59,000	236,000	8	49
Leith, Nevada	3.5	10.2	114	45,500	182,000	6	37
Anderson Jct, Utah	2.0	15.2	104	41,800	167,000	5	34
Gunlock, Utah	2.0	11 0	73	29,400	117,000	4	28
Lucas, Utah	2.0	15.0	105	43,000	172,000	5	34
Kanarra, Utah	2.5	15 4	147	52,000	208,000	7	43
Veyo, Utah	8.0	10 1	262	105,000	420,000	13	86
New Harmony, Utah	.29	35.8	39	15,500	62,200	2	13

Table III (Cont'd)

Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Density μμc/cm^2	I-131 in Fresh Milk μμc/l based on: Windscale	Garner	Dose to Infant Thyroid - Rads Windscale	Garner
SHOT DIABLO - 15 JULY 1957 - 17 Kt. - 500' - TOWER							
Bardoli Ranch, Nev	2.5	12.3	101	40,500	162,000	5	33
Belen Ranch Adaven, Nevada	8.5	11.5	286	115,000	460,000	14	95
Ely, Nevada	3.7	14.4	179	71,500	286,000	9	59
Geyser Ranch, Nev	7.0	16.7	416	166,000	660,000	21	137
Groom Mine, Nevada	75	8.2	1,890	760,000	3,000,000	94	625
Lincoln Mine, Nev	52	8.0	1,310	525,000	2,100,000	65	430
Lund, Nevada	4.4	13.0	1,940	780,000	3,110,000	97	640
Preston, Nevada	4.2	13.2	1,850	740,000	2,970,000	93	610
South Paw Mine, Nev	12.5	11.3	459	180,000	735,000	23	150
Sunnyside, Nevada	8.7	11.2	320	128,000	510,000	16	105
Uhalde Ranch, Nev	11.0	8.4	277	111,000	444,000	14	100
Watch Pine Creek Ranch, Nevada	4.5	14.5	218	87,000	350,000	11	72
Whipple Ranch	1.5	12.5	60	24,300	97,000	3	20
SHOT KEPLER - 24 JULY 1957 - 10.3 Kt. - 500' - TOWER							
Basalt, Nevada	1.5	13.0	66	26,500	106,000	3	22
Coaldale, Nevada	9.5	13.0	420	167,000	670,000	21	138
Goldpoint Nevada	6.5	9.2	188	75,400	300,000	9	62
Silverpeak, Nevada	7.5	11.9	304	122,000	486,000	15	100

Table II (Cont'd)

Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Density c/cm²	I-131 in Fresh Milk c/l based on: Windscale	Garner	Dose to Infant Thyroid - Rads Windscale	Garner
SHOT OWENS - 25 JULY 1957 - 9.7 Kt. - 500' - BALLOON							
Bardoli Ranch, Nev	1.7	7.1	33	13,400	53,500	2	11
Currant, Nevada	5.5	5.8	80	32,000	128,000	4	26
El Dorado, Nevada	1.4	9.9	46	18,400	73,500	2	13
Eureka, Nevada	1.3	8.0	33	13,100	52,500	2	11
Fallini Ranch, Nev	1.8	5.3	26	10,400	41,600	1	9
Nyala, Nevada	2.5	6.7	45	18,100	72,500	2	15
SHOT SHASTA - 18 AUGUST 1957 - 16.5 Kt. - 500' TOWER							
Bardoli Ranch, Nev	4.8	10.3	157	63,000	252,000	8	52
Currant, Nevada	3.5	8.7	88	35,300	141,000	4	29
Eureka, Nevada	13.0	10.5	430	172,000	688,000	21	142
Fallini Ranch, Nev	33.0	6.9	710	285,000	1,140,000	35	235
Lockes, Nevada	7.0	8.1	176	70,500	282,000	9	58
Lund, Nevada	2.5	10.6	82	32,800	131,000	4	27
Nyala, Nevada	6.0	8.7	151	60,500	242,000	8	50
Preston, Nevada	3.5	10.2	115	46,000	183,000	6	38
Reveille Mill, Nev	20	6.0	362	145,000	580,000	18	120

TABLE III (Cont'd)

Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Density c/cm²	I-131 in Fresh Milk c/l Windscale	Garner	Dose to Infant Thyroid - rads Windscale	Garner
SHOT SMOKY - 31 AUGUST 1957 - 44.0 Kt. - 700' - TOWER							
Butler Ranch, Nev	360	3.8	2,380	1,150,000	4,600,000	144	950
Glendale Jct, Nov	2.0	12.4	81	32,400	130,000	4	27
Mesquite, Nevada	2.0	13.6	88	35,100	141,000	4	29
Fox, Nevada	8.8	8.5	222	89,000	355,000	11	73
Anderson Jct, Nev	11.0	10.7	360	144,000	578,000	18	119
Cedar City, Utah	3.0	11.9	110	44,000	176,000	5	36
Central, Utah	6.0	10.9	98	39,300	157,000	5	32
Gunlock, Utah	7.0	9.7	203	81,000	325,000	10	67
Hurricane, Utah	2.5	12.2	101	40,000	160,000	5	33
Leeds, Utah	17	9.5	494	197,000	790,000	24	163
Rockville, Utah	2.0	12.8	81	32,400	130,000	4	27
St. George, Utah	14.0	12.5	467	227,000	910,000	28	187
Veyo, Utah	15	10.0	491	196,000	786,000	24	162
Virgin, Utah	2.0	12.6	81	32,400	130,000	4	27
Washington, Utah	4.0	11.6	147	58,700	235,000	7	48
Rock Springs, Wyo	5.0	12	203	81,000	324,000	10	67
SHOT GALILEO - 2 SEPTEMBER 1957 - 11.4 Kt. - 500' - TOWER							
A & B Mine, Nevada	3.0	13.4	132	53,000	220,000	6	43
Fallini Ranch, Nev	0.8	14.7	39	15,500	62,000	2	13
Parmon Ranch, Nev	0.9	14.0	40	16,000	64,400	2	13
Reveille Mill, Nev	3.5	11.7	128	51,400	205,000	6	42
Stone Cabin Ranch	2.3	10.8	75	30,000	120,000	4	25

Table IV

Some Estimated Infant Thyroid Doses for 1958 (Operation Hardtack-II)[14]

| Hot Spot Location	Rate mr/hr	Time of Reading H + hrs	I-131 Density c/cm²	I-131 in Fresh Milk c/l based on:		Dose to Infant Thyroid - Rads	
				Windscale	Garner	Wind-scale	Garner
SHOT ___ - 10 OCTOBER 1958 - 79 Kt. - 100' - TOWER							
Beatty, Nevada	1.4	7.7	30	12,000	48,000	2	10
Hwy 58 10 mi N of Beatty, Nevada	2.5	4.92	36	14,500	57,000	2	12
SHOT LEA - 13 OCTOBER 1958 - 1500' - BALLOON							
8 mi. W of Cliff Spring, Nevada	1.5	9.3	43.5	17,400	70,000	2	14
8 mi W of Reed on old hwy 25	3.3	9.3	96	37,000	153,000	5	32
SHOT RIO ARRIBA - 18 OCTOBER 1958 - 90 Kt. - 70' - TOWER							
Below Ranch, Nev	1.8	7.5	39	15,500	62,000	2	13
Casey Ranch, Nev	1.4	8.0	35	14,100	56,400	2	12
Sharp Ranch, Nev	1.5	8.3	38	15,100	60,400	2	13
Uhalde Ranch, Nev	1.7	7.3	37	14,700	59,000	2	12
Walch Ranch, Nev	1.6	6.6	29	11,600	46,400	1	10

NEVADA
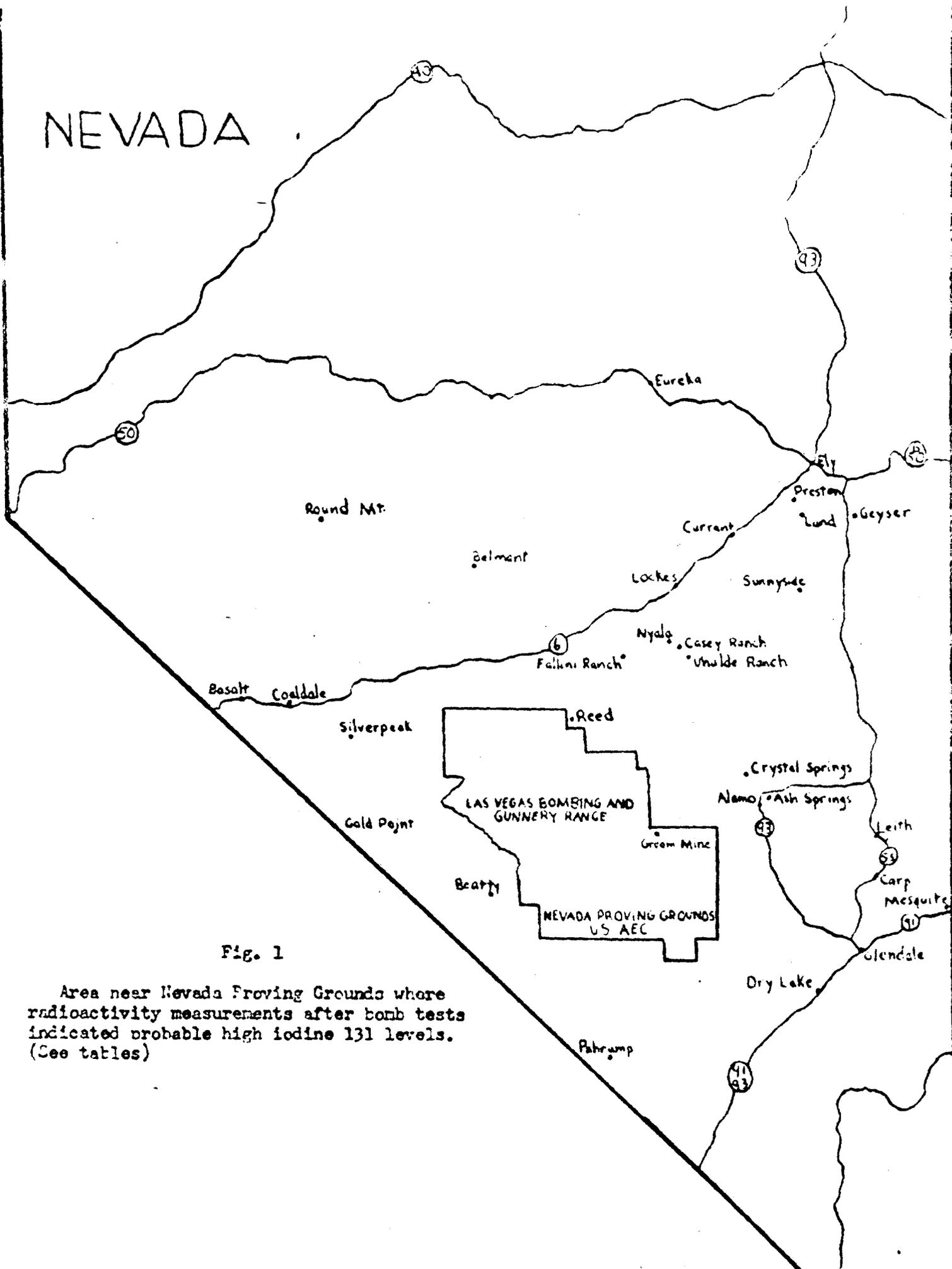
Fig. 1

Area near Nevada Proving Grounds where
radioactivity measurements after bomb tests
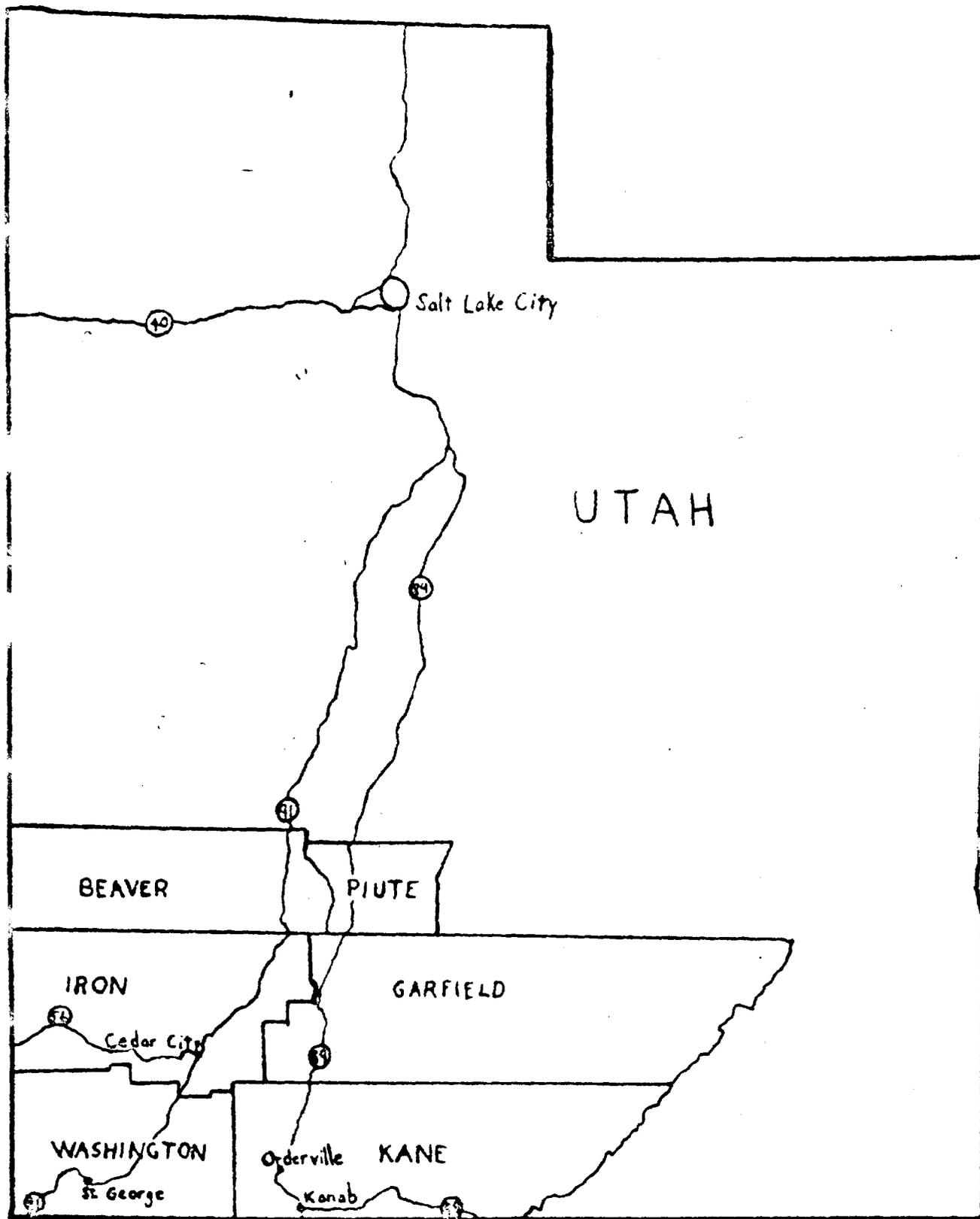indicated probable high iodine 131 levels.
(See tables)

Fig. 2

Area in Utah where radioactivity measure-
ments after bomb tests indicated probable
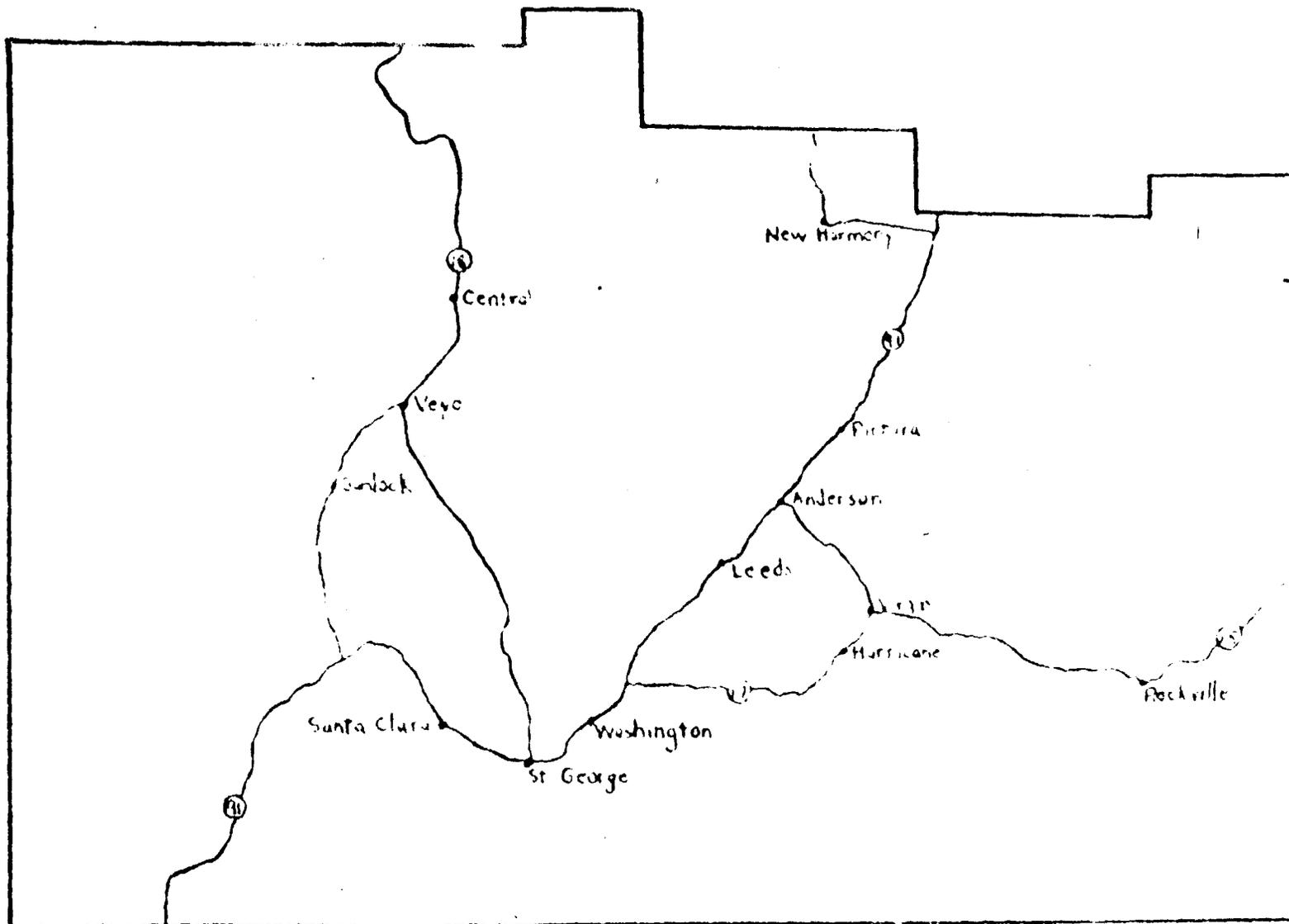high iodine 131 levels. (See tables)

Fig. 3

Washington County, Utah with points at
which repeated high radioactivity measure-
ments indicate probable high iodine 131
levels for most of the county. (see tables)

fallout sufficiently intense to result in medically signi-
ficant radiation exposure to childrens' thyroids in an
appreciable number of instances.

Some locations in the Nevada region have received such
possible dosages on repeated occasions.

Currant, Nevada, for instance, a town of about 75 people
located about 80 miles north of the test site, received
significant doses on March 7, 1955; May 5, 1955; May 28, 1957;
July 15, 1957; July 25, 1957; and August 18, 1957. Infant
thyroid doses would all be greater than 2.5 rads, and in 4
cases out of the 5, could have exceeded 25 rads. Another
example is Lockes, Nevada which received three significant
doses, all of which were 10 rads or more by the lower
estimate. By the higher estimate, the doses on two occasions
may have exceeded 100 rads.

Washington county, Utah is one of the most heavily popu-
lated of the areas to receive heavy fallout depositions. It
is an area in which, on at least one occasion (May 19, 1953),
citizens in several communities were asked to stay indoors
for several hours after a test shot. Fallout on that date
blanketed the entire county. Infant thyroid doses due to
contaminated milk might have reached from 150 to 950 rads
in Hurricane, Utah, and it is very likely that the minimum
dose for infants in most of the county due to milk from
cows fed fresh pasturage was about 50 rads.

The largest town in Washington County, St. George,
(population 5,000) received possible maximum doses of

Table ?

Some Estimated Infant Thyroid Doses in Fresh Fallout from the Nevada Test Site,
for 1952 (Operation Tumbler-Snapper) and 19?? (Operation Upshot-Knothole)[15,16]

Hot Spot Location	Gross activity x 10?	Average Time of ending H + hr.	I-131 Density c/cm^2	I-131 in Fresh Milk c/l based on:		Dose to Infant Thyroid - rads	
				Windscale	Garner	Wind-Scale	Garner
SHOT EASY - 7 MAY 1952 - 12 Kt. - 300' - TOWER							
Salt Lake City, Utah	23	12	54.1	21,600	86,500	3	18
SHOT GEORGE - 1 JUNE 1952 - 14.6 Kt. - 300' - TOWER							
Pocatello, Idaho	4.2	12	9.9	3,950	15,?00	.5	3
Norfolk, Nebraska	.78	60	11.3	4,520	18,100	.6	4
Terre Haute, Indiana	1.38	36	11.5	4,500	18,000	.6	4
Grand Rapids, Mich	1.2	36	9.8	3,900	15,600	.5	3
SHOT HOW - 5 JUNE 1952 - 13.9 Kt. - 300' - TOWER							
Boise, Idaho	17.7	12	41.6	16,600	66,500	2	14
Great Falls, Montana	10,8	12	25.2	10,200	40,600	1	8

Table V (Cont'd)

Hot Spot Location	Gross d/m/ft^2 x 10^6	Average Time of Reading H + Hr.	I-131 Density c/cm^2	I-131 in Fresh Milk c/l based on:		Dose to Infant Thyroid – Rads	
				Windscale	Garner	Wind-Scale	Garner
SHOT ANNIE – 17 MARCH '53 – 16.2 Kt. – 300' – TOWER							
Knoxville, Tennessee	1.9	36	15.5	6,200	24,800	.8	5
SHOT NANCY – 24 MARCH 1953 – 24.4 Kt. – 300' – TOWER							
Salt Lake City, Utah	15.0	12	35.3	14,100	56,400	2	12
Ely, Nevada	6.3	12	14.8	5,900	23,700	.7	5
Rapid City, S. D.	2.04	36	16.6	6,700	26,600	.8	6
SHOT DIXIE – 6 APRIL 1953 – 10.9 KT. – 300' – TOWER							
Boston, Mass	5.1	36	41.6	16,600	66,500	2	14
SHOT BADGER – 18 APRIL 1953 – 23 Kt. – 300' – TOWER							
Port Arthur, Texas	1.5	36	12.2	4,900	19,600	.6	4
SHOT SIMON – 25 APRIL '53 – 42.7 Kt. – 300' – TOWER							
Grand Junction, Colo	2.9	36	23.6	9,500	37,800	1	8
Roswell, N. M.	13.0	36	106	42,400	170,000	5	35
Albuquerque, N. M.	2.4	36	19.6	7,800	31,300	1	6
Albany, New York	16	36	131	52,100	209,000	7	43
SHOT HARRY – 19 MAY 1953 – 32.4 Kt. – 300' – TOWER							
Grand Junction, Colo	11	12	25.9	10,300	41,400	1	9
Des Moines, Iowa	1.5	36	12.2	4,900	19,600	.6	4
Albuquerque, N. M.	7.8	12	18.4	7,700	29,400	1	6

25-165 rads on March 17, 1953; 110-735 rads on May 19, 1953;
7-42 rads on March 1, 1955; 4-29 rads on May 15, 1955;
and 28-185 rads on August 31, 1957.

These doses are representative of the whole of
Washington county.

The August 31, 1957 value was due to shot "Smoky" of
Operation Plumbob. Fallout from this explosion resulted in
measurements indicating infant thyroid doses of 10-67 rads
over an 8000 square mile area outside the Test Site, of
which Washington county comprised 2500 square miles. Equally
high levels were reported as far away as Rock Springs, Wyoming,
700 miles from the Test Site.

Cases of relatively high thyroid doses in locations
distant from the Nevada Test Site appear to be fewer than
near the Site, although this may be due in part to the fact
that monitoring outside the test area is even less extensive
than for the region within a 200 mile radius. One distant
case was that in Troy, New York on April 26, 1953. Contam-
ination of milk was not measured at that time but Ralph Lapp
estimates that iodine 131 in milk might have reached 100,000
$\mu\mu$c per liter. As a result, infants may have received doses
to the thyroid as high as 30 rads.

During 1952 and 1953, one to ten rad doses or more to
infant thyroids may have occurred in areas near Salt Lake City
on May 7, 1952 and again on March 24, 1953; at Boise, Idaho
and Great Falls, Montana on June 5, 1952; Boston, Massachusetts

on April 17, 1953; Grand Junction, Colorado, Roswell,
and Albuquerque, New Mexico (as well as Troy and Albany,
New York) on April 26, 1953, and Grand Junction again on
May 19, 1953.

4) Were the theoretically possible doses actually
   received by childrens' thyroids as a result of
   fallout from the Nevada Test Site?

It has already been pointed out that the above estimates
are theoretical, in that they show what thyroid radiation
dosages might result, providing that the iodine 131 in the
deposited fallout actually entered the food chain and was
ingested by children locally from locally-produced milk.

What is the likelihood that such doses did actually
occur? Two conditions must have been met: that there were
milk cows grazing in the contaminated pastures, and that
children drank the milk. Monitoring reports have rarely
supplied information of any detail on these questions
(no detailed information is available for the tests held
in 1952, 1955 and 1958; for 1953 testing, one survey to
check for grazing animals in areas of high fallout was
reported; and for 1957 testing, and again for 1961 and 1962,
milk monitoring data of limited value are available). Census
reports, however, indicate that there were 4438 milk cows
on the farms and ranches in Lincoln, Nye, Clark, Elko and
White Pine counties, in Nevada (the areas closest to the

MILK COWS IN SEVERAL ... NEVADA TEST SITE

County	State	1950		1954		1959	
		Farms Reporting	Milk Cows	Farms Reporting	Milk Cows	Farms Reporting	Milk Cows
Washington	Utah	556	1898	469	2127	519	1630
Iron	"	324	??	259	??0	2??	799
Clark	Nev.	157	14??	108	1565	83	2096
Elko	"	251	1155	213	791	161	493
Lincoln	"	103	??	78	444	60	459
Nye	"	87	350	26	340	64	318
White Pine	"	111	801	86	642	83	554

SIZE OF HERDS, 1959
Number of Cows in Herd

		1	2-9	10-19	20-29	30-49	50+
				Number of Herds			
Washington	Utah	148	136	10	11	11	3
Iron	"	81	103	5	6	4	1
Clark	Nev.	27	32	1	3	7	13
Elko	"	37	121	3	none	none	none
Lincoln	"	18	32	3	3	2	2
Nye	"	29	33	1	none	none	1
White Pine	"	21	52	1	1	6	2

test site) in 1950. These same counties had 3782 milk cows in 1954, 3920 in 1959. Only one county, Nye, consistently reported fewer than 500. A more detailed report for 1959 indicated that out of 451 farms reporting in these counties; 402 of these had between one and nine; and 49 had herds of 10 or more.

Washington county, Utah (which has received repeated high fallout, as noted earlier) had 1898 milk cows in 1950, 2127 in 1954 and 1660 in 1959. In 1959 219 farms reporting had one to nine milk cows and the remaining 100 had 10 or more.

The one detailed survey in 1... ? ... ... hit a
point 75 miles northeast of the test site... March ..., 1953
and seven herds of milk cows ... ... St. George, Utah on
May 19, 1954. The cows ... ... on that date, ... date
of shot "Harry.")[8] This corresponds to contamination on their
pasture which may have caused infant thyroid doses from 100
to 1000 rads.

Were there infants and children in the area to drink
this milk? 1960 census figures (these figures vary little
from year to year) indicate about 20,000 children under 5

Table VII
POPULATION STATISTICS FOR SELECTED COUNTIES NEAR THE NEVADA TEST SITE

1950

County	State	Total Pop.	Per cent residence rural farm	Per cent under 5 years old	Live Births
Washington	Utah	9,836	23	data for	332
Iron	"	9,642	10	this age	306
Clark	Nev.	48,289	24.2	group	1,247
Elko	"	11,654	17.6	not	254
Lincoln	"	3,837	10.6	available	91
Nye	"	3,101	16	for 1950	53
White Pine	"	9,424	8.6		232

1960

County	State	Total Pop.	Per cent residence rural farm	Per cent under 5 years old	Live Births
Washington	Utah	10,271	5.2	12.8	230
Iron	"	10,795	3.9	13	274
Clark	Nev.	127,016	1	12.4	3,554
Elko	"	12,011	13.7	11.3	292
Lincoln	"	2,431	6.0	11.9	56
Nye	"	4,374	10.1	9.5	64
White Pine	"	9,808	4.3	12	208

years of age, and 4174 live births per year in the counties
of interest in Nevada. In Washington county, Utah, there
were 628 children under 5 in 1960, 285 live births in 1960
and 332 live births in 1950. This indicates that there were
approximately 250 to 300 children of 6 to 18 months in the
county at any given time.

Individual children on any of a large number of ranches
could have received high thyroid radiation doses (such as,
for instance, the 21 to 137 rads possible at the Geyser Ranch
in Nevada on July 15, 1957). There are repeated cases in
which we know it is quite likely that a considerable number
were exposed. The entire Washington county was blanketed
with fallout levels that could cause 5-100 rad or higher
doses on at least 7 different occasions.

Not only was fresh milk on farms probably affected, but
also pasteurized milk, for much of the milk delivered in the
county is not mixed with milk from other areas. St. George
has one local dairy, the Whitehead Dairy, which collects milk
only in Washington County, in the immediate vicinity of
St. George, and distributes it locally. The Arden Meadowgold
Dairy collects its milk in nearby Iron, Piute and Beaver
counties. These dairies have been in business throughout
the period under consideration with the same collection and
distribution pattern.[19]

Pasteurized milk from these dairies would be expected
to have iodine levels lower by a factor of .85 than the

fresh milk from the area. This is due to the decay in radioactivity taking place in two days--the time it takes to collect, process and distribute the milk.

(Other dairies active in Washington County are the Anderson Dairy, which ships milk out to Las Vegas, where it is presumably pooled with other milk, and the Highland Dairy, which has come in more recently, distributing milk from northern Utah.)

The chain, therefore, from nuclear explosion through fallout, pasture, cow and milk to children has been completed in many of these areas and for a considerable number of children. What biological effect would be expected from these exposures?

5) The biological significance of these levels

It is now well known that radioactive iodine presents a special hazard to infants for the following reasons:

1. Milk is the largest human dietary source of iodine 131 and children generally drink more milk than adults.

2. For the same quantity of iodine in the food eaten, the cells of the thyroid of an infant receive 10 to 15 times the dose received by the cells of an adult thyroid. The infant thyroid is much smaller, generally weighing about 2 grams, whereas the adult thyroid weighs about 20 grams. In the infant a given quantity of radiation is spread over a much smaller mass, and each gram receives a greater amount of radiation.

3. The infant's thyroid may be more sensitive than the adult's to cancer induction by radiation. Thyroid cancer was observed in children after a single exposure to radiation of 150 rem.[4]

The Federal Radiation Council, in its Report No. 2 discusses the carcinogenic effect of radiation on the thyroids of children, drawing upon the evidence of significantly higher incidence of carcinoma in children who had been exposed to x-irradiation in the neck region, than in control groups not so exposed.

The smallest dose capable of inducing cancer is not known, but it is generally assumed that the frequency of induced cancer may be proportional to dose, down to very low levels of exposure. On the assumption of no threshold, Beach and Dolphin of the United Kingdom Atomic Energy Authority estimate that if one million infants were exposed to one rad of thyroid radiation, 35 would be expected to develop thyroid cancer.

The AEC's permissible external effective biological dose of 3.9 r could result in an internal thyroid dose of 175 to 1200 rads, and actual exposures, as we have shown, may have ranged from well below to well above this dosage.

6) Underground tests

Significant radiation levels from continental testing have not been confined to surface and atmospheric shots. Venting of subsurface shots has been reported for at least seven cases: March 23, 1955 (shot ESS, of Operation Teapot); September 15, 1961; December 10, 1961 (Project Gnome); March 5, 1962; April 14, 1962; May 19, 1962; June 13, 1962 (the Des Moines shot) and July 6, 1962 (the Sedan shot, 100 kiloton shot 635 feet underground).[1,20,21] The Des Moines shot resulted

in a peak of 1240 μc/liter in milk of Spokane, Washington
on June 21. According to a Weather Bureau study "The initial
appearance phase (July 8-11) for I-131 in milk (in Salt
Lake City) would appear to have been due to the July 6 (Sedan)
test."[21]

The Gnome shot in New Mexico may have resulted in thyroid
doses in the range from 7 to 55 rads in the immediate vicinity
of Carlsbad.

7) Limitations of these estimates

Any objective appraisal of the estimates made here
must take into account their limitations.

The main problem is a general lack of useful data.
In most cases, detailed milk data was not reported, and when
it was, the information was not in usable form.

Table VIII

Some estimated infant thyroid doses for Project Gnome (December 10, 1961).
Data are from AEC report number PNE-132F.

Hot Spot Location	γ Rate mr/hr	Time of Reading H + hrs	I-131 Density μμc/cm^2	I-131 in Fresh Milk μμc/l based on: Windscale	I-131 in Fresh Milk μμc/l based on: Garner	Dose to Infant Thyroid - Rads Windscale	Dose to Infant Thyroid - Rads Garner
Roswell, New Mexico	.3	10.17	9.84	3,940	15,700	.5	3
7.4 mi W Jct 31 & 285 on 31	7.0	13.77	339	135,000	542,000	17	102
3.6 mi E of Carlsbad on 62/180	4.0	10.25	131	52,000	210,000	7	43
40 mi E Pecos Bridge on 62/180	5.0	9.75	164	65,600	262,000	8	54

In 1953, some observations of dairy herds were made, and external doses received by them were estimated, but actual data on fresh milk given just after the exposures are not available. In 1957, during Operation Plumbob, milk was tested, but only for gross beta radiation and for strontium 90. The gross beta values do not provide a basis, in this case, for inferring iodine levels, and while calculations can be made from strontium levels, they do not carry the same certainty as actual iodine figures.

Detailed milk monitoring figures were not reported for the 1958 test series, Operation Hardtack II. The two tests for which such monitoring was reported were Project Gnome, December 10, 1961, at Carlsbad, New Mexico and the Des Moines shot, June 13, 1962. However, all iodine measurements for Gnome were made in milk collected either before the test, or at least one month after the test, when any high levels that might have occurred had already dissipated.[22]

For the Des Moines test milk was again monitored either too early (June 13, the day of the test) or too late.[23] Concentrations of 600 and 500 micromicrocuries per liter were found at two locations on June 20 and 21, but the actual peaks at those locations would have come about June 15-17, two to four days after the explosion.

More adequate data either have not been taken, or have not been made available to the public. (A report by the

AEC, "Safety at the Nevada Test Site," 196 asserts "All of
the essential data from these m. .toring programs have been
reported in the open literature.[14])

For areas distant from the Nevada Test Site, there are
no milk data for the period before 1957, and data taken after
that time have usually represented an area-wide, monthly
average, so that detailed variations are obscured.

The limitation on the fallout monitoring program is clear
from its budget. As stated in the 19 Fallout hearings,
Phase I, offsite monitoring costs run about $3/4 million
per year.

At the 1957 hearings on fallout, the AEC stated, officially,

> These two isotopes - radio strontium and radioiodine -
> constitute the principle internal hazards from the
> radioactives produced by the detonation of atomic
> weapons, both fission and thermonuclear. The Atomic
> Energy Commission has been engaged for three years
> in a broad study of the radioactive forms of these
> isotopes and conducts year-round monitoring of
> these radioactivities in many locations. Any accu-
> mulation of these materials can be detected with
> great sensitivity so that ample warning of potential
> hazard could be given long before any actual danger
> occurred from test detonations. The amounts of
> radiostrontium and radioiodine which have fallen
> outside the areas near the test sites as a result of
> all atomic tests up to now are insignificant compared
> to concentrations that would be considered hazardous
> to health.

and

> The hazard has been successfully confined to the
> controlled area of the Test Site.

In the light of the present analysis, these statements
are an incorrect estimate of the hazard to the local popu-
lation from fallout in the Nevada Test Site region.

1. "The Nature of Radioactive Fallout and its effect on man," Hearings before
   a subcommittee of the Joint Committee on Atomic Energy, May 27-June 7, 1957.

2. Federal Radiation Council. Report no. 2, May, 1961.

3. Pate, Brian D. "Short-Lived Radioactive Debris from Nuclear Weapons Tests,"
   Nuclear Information, Jan., 1962.

4. Wurtz, Robert H. "The Iodine Story," Nuclear Information, Sept., 1962.

5. Lapp, Ralph, "Nevada Test Fallout and Radioiodine in Milk," Science, 141:640, 1963.

6. "Biological and Environmental Effects of Nuclear War, Hearings before a subcom-
   mittee of the Joint Committee on Atomic Energy, June 22-26, 1959.

7. Garner, R. J. "An Assessment of the Quantities of Fission Products Likely to be
   Found in Milk in the Event of Aerial Contamination of Agricultural Land," Nature,
   186:1963, June 25, 1960.

8. Collison, Tom D. "Report to the Test Director: Radiological Safety Operation."
   June, 1953. AEC report no. WT 817

9. Collison, Tom D. "Report to the Test Director: Radiological Safety Operation."
   March-June, 1953. AEC report no. T 702.

10. LeVine, H. D., and R. T. Graveson. "Operation Teapot, Measurements of Off-
    site Fallout by Automatic Monitoring Stations." June 26, 1957. AEC report
    no. WT 1186.

11. Placak, O. R., et al. "Operation Plumbob Off-site Radiological Safety Report."
    1957. AEC report no. OEO-57-3.

12. Larson, K. H., et al. "Summary Statement of Findings Related to the Distribution,
    Characteristics and Biological Availability of Fallout Debris originating from
    Testing." 1960. AEC report no. WT 458.

13. Sigoloff, S. C., and H.M. Borella. "Operation Plumbob, Remote Radiological

Monitoring.", May, 1949, AEC report no. ___ __ __.

14. Placak, O.R. et al. "Operation Hardtack Phase II, Off-Site Radiological Report, Nevada Test Site, 1958," Aug., 1959. AEC report no. CR-59-4.

15. List, R.J. "Radioactive Debris from Operation Tumbler and Snapper. Observations beyond 200 miles from the Test Site. Part II" 1953. AEC report no. NYO 4512.

16. List, R.J. "The Transport of Atomic Debris from Operation Upshot-Knothole." June 25, 1954. AEC report no. NYO 4602.

17. Census of Agriculture, 1954 and 1959.

18. U.S. Bureau of Census, City and County Data Book. A Statistical Abstract Supplement. Editions for 1952 and 1962.

19. Personal communication from Whitehead Dairy, St. George, Utah.

20. U.S. Public Health Service, Radiological Health Data, July, 1962, p. ii.

21. U.S. Public Health Service, Radiological Health Data, 3:510 (Dec., 1962).

22. Placak, O.R. "Project Gnome, Carlsbad, New Mexico, Off-site Radiological Safety Report, 1961," May 22, 1962. AEC report no. PNE-132-F.

23. U.S. Public Health Service, Radiological Health Data, 3:402 (Oct., 1962).

24. "Fallout, Radiation Standards, and Countermeasures," Hearings before a subcommittee of the Joint Committee on Atomic Energy, June 3-6, 1963, Part One.