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11. SUPPLEMENTARY NOTES Many of the data contained in this report comes from discussions and briefings. In addition, on 2 December 1991, several scientists from the Institute of Biophysics of the USSR Ministry of Health, Chelyabinsk Branch Office, who have studied the Kyshtym and Chelyabinsk nuclear accidents for decades, presented human data at AFRI that have never before been released to the West.

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13. ABSTRACT (Maximum 200 words) Three nuclear accidents besides Chernobyl have occurred in the Former Soviet Union (FSU). The accidents occurred over the geographic area around Kyshtym and Chelyabinsk in the Urals between 1949 and 1967 and contaminated over half a million people. The first accident occurred in 1949-1951, the second on 29 September 1957, and the third in 1967, and involved the air transfer of irradiated sand particles. Although these accidents occurred between 25 and 43 years ago, the first official admission by the FSU was made in June 1989, and it was only during late November 1991 that the FSU declared a national disaster emergency concerning the affected area. The health ministries are now interested in data previously collected from these irradiated populations to examine health effects, including cancer, and genetic damage in humans. Data collected from these large populations and occupationally exposed workers offer a unique opportunity to quantify the adverse health effects of chronic exposure to fission products, reactor neutrons and environmental chemicals.

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Nuclear Accidents in the Former Soviet Union:

Kyshtym, Chelyabinsk, and Chernobyl

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INTRODUCTION

In September 1991, three weeks after the attempted putsch, I represented the Defense Nuclear Agency/Armed Forces Radiobiology Research Institute as part of a United States Information Agency (USIA) contingent in Moscow and St. Petersburg, Russia. I met numerous scientists that were and are currently involved in all the nuclear accidents that occurred in their country. Much of the data contained in this report comes from discussions and briefings. In addition, on 2 December 1991, several scientists from the Institute of Biophysics of the USSR Ministry of Health, Chelyabinsk Branch Office, who have studied the Kyshtym and Chelyabinsk nuclear accidents for decades, presented human data that have never before been released to the West.

The radiation situations in the area of Kyshtym and Chelyabinsk are unique because over the last 40 years masses of people have been exposed to ⁹⁰Sr in the food and water chain. Basic dosimetry investigations focused on

the doses of ^{90}Sr . The first estimates of exposure were from nuclide measurements taken from the river sediment. These analyses began in 1951, one and a half years after the accident occurred.

ACCIDENTS

In 1948, the U.S.S.R. began operating a plutonium production plant called **Mayak** in the Kyshtym/Chelyabinsk region. In 1949-1951, an accident released 3 million Ci of radiation into the Techa River (Degteva, 1991, see Figure 1). A second accident occurred in 1957, southeast of Kyshtym, when improperly ventilated storage tanks exploded, and 20 million Ci of radioactive waste were released into the atmosphere (Akleev, 1991). The storage complex was located 1.5 Km from the reprocessing plant and consisted of 60 underground storage tanks. The radionuclide composition of the fallout indicated it was comparatively fresh nuclear waste from reprocessing, stored for not more than 6-7 months, from which not only uranium and plutonium but also cesium had been removed (Medvedev, 1991).

Due to the confined nature of the blast, the majority (90%) of the nuclear waste dispersed near the tanks in the form of a liquid pulp (Burnazyan, 1990). However, a plume cloud with an activity of 2 million Ci dispersed its contamination over the area shown on the map in Figure 1. The contaminants from the plume cloud were confined to the Chelyabinsk and the Sverdlovsk provinces. Before the accident, more than 28,000 people lived in the 38 villages along the Techa River. Dosages of ^{90}Sr exceeded 0.01 Ci/km^2

and were distributed over 23,000 km² (Kosenko, 1991). The highest concentration of ⁹⁰Sr was located in an area known as Metlino, located near Kyshtym (see Figure 1). The doses in the Metlino area averaged 3 Sv/km². The dispersion of radioactivity from the plume cloud is shown by the map in Figure 1.

In the spring of 1967, a third accident occurred resulting in an air transfer of radioactive sand particles from the beach of Lake Karachay (Akleev, 1991). This lake is located due west of Argayash. A total of 600 Ci ¹³⁷Cs and ⁹⁰Sr was released by the air transfer of sand particles from the Lake Karachay beach (Akleev, 1991). Radiation from this accident was primarily gamma radiation along the Techa River and reached 5R/hour (Kosenko, 1991). The average activity along the Techa River was 10⁻⁵ Ci/liter of water. A massive three month cleanup between the summer and autumn of 1967 (Degteva, 1991), resulted in a ten fold decrease in radiation levels. This occurred because the Soviets removed all the water from the contaminated reservoir located near the Metlino area (Degteva, 1991). [NOTE: We were not told where the water was moved to nor how it was disposed of.]

DISCUSSION

In the aftermath of the Kyshtym accident, if a village was found to be radioactive it was scheduled for evacuation as political circumstances dictated (Soyfer, 1991). In addition to the area dosimetry, which measured

river sediment for contamination, human dosimetry began in the summer of 1951 measuring body excrement and contaminated clothes (Degteva, 1991). It should be noted, that during this 1.5 year hiatus between the accident and the beginning of dosimetry measurements, the people were neither informed of the accident nor of their (internal or external) exposure to any form of ionizing radiation (Soyfer, 1991). Consequently, all the food and water consumed during this time period was contaminated with radiation (Akleev, 1991).

In an attempt to further quantify dosimetry from the Kyshtym and Chelyabinsk accidents, the bones of deceased persons were exhumed during the 1960's and resulted in the creation of a data base that reflected their "lifetime" exposures to ^{90}Sr (Kosenko, 1991). In 1974, the Soviets created a data base using live subjects to determine their whole-body doses of ^{90}Sr . The methodology used to make these determinations included dosimetric examinations of urine samples and frontal lobes (Douplenski, 1991). The urine samples were obtained from 1,500 residents living beside the Techa River (Kosenko, 1991); the 12,500 subjects involved in the frontal lobe study also lived along the Techa River (Kosenko, 1991). The teeth of 15,000 living subjects in this area were also examined for ^{90}Sr doses (Kosenko, 1991). The location from which these residents were evacuated is known today as the "Post Box Chelyabinsk-40" area (Medvedev, 1991).

The results show that 1,000 people living by the Techa River had greater than 1 mCi of ^{90}Sr in their bones (Kosenko, 1991). Further analyses showed

that these people born in 1932-1933, and were teenagers during the first accident, accumulated three to five times more ^{90}Sr than did those who were adults at the time of the first accident (Akleev, 1991). The maximum reading of 6 mCi per person occurred in those individuals that were teenagers during the time of the accidents (Akleev, 1991). Measuring the metabolism measurements of ^{90}Sr and overlaying them with all three previous accidents provided the following results: The exposure levels averaged 0.42 Sv along the Techa River to the southwest, 0.52 Sv along the middle portion of the Techa River, and 2 Sv near Chelyabinsk (Degteva, 1991). The three accidents affected 437,000 people (Kosenko, 1991). Of these, 1,200 people obtained 200 rems over a 2 year period (Kosenko, 1991). In addition, some people received doses of up to 400 rems to their bone cells (Kosenko, 1991).

RELOCATION

Of the 39 villages along the Techa River before the accident, only four villages are safe to inhabit today (Akleev, 1991). An analysis of people along the Techa River show decreased leukocyte immune system functioning (Akleev, 1991). This is attributed to the 3- year period when people daily drank the radioactive water and ate contaminated food before their relocation (Douplenski, 1991). The average time of relocation took 8 years to complete (Degteva, 1991). The time range for relocation spanned 3-11 years for evacuating all residents from the 35 contaminated villages along the Techa River (Douplenski, 1991; Medvedev, 1991). The total number of people moved during this time exceeded 10,500 (Akleev, 1991). After the

people were relocated the villages were incinerated to ensure that no human habitation would occur in this highly radioactive area. However, the heat and smoke created by the incineration process spread the contamination over the streams, rivers and lakes further contaminating the food chain for animals and humans.

One exception to the protracted relocation of residents living in the contaminated areas occurred out of necessity. Following the Kyshtym accident, 1,154 residents of Kasli, near Kyshtym, were removed 7-10 days after the accident, due to extremely high ^{90}Sr levels (Akleev, 1991). People that were removed during this time period, now have twice the acute myeloid leukemias that the control groups have exhibited (Akleev, 1991).

An historical note, the construction of the radioactive facilities was conducted between 1945-1948 by approximately 70,000 inmates from 12 labor camps (Douplenski, 1991). The Kyshtym location is N 55-44, E 60-35. The Kyshtym restricted area covers 2700 sq/km and contains eight lakes with interconnecting watercourses. The Kyshtym atomic plant is situated in a tunnel, which extends beneath a river, with only a smoke stack visible from the air or ground. During the construction process, one lake was drained, a building was built on its lakebed with cement, rubber and lead, then the lake was refilled (Medvedev, 1979). During the cold war several high altitude, reconnaissance aircraft routinely photographed this area. In 1960, Major Francis Gary Powers was shot down by a surface-to-air missile while flying over the Kyshtym, Chelyabinsk atomic facilities.

CONTROL GROUPS

Two control groups were selected for comparison purposes for this longitudinal field study of irradiated humans (Degteva, 1991). The control groups were located just south of this area and were not involved in the radiation. The first control group consisted of 34,000 persons of the same socioeconomic status as the victims and had no access to the contaminated Techa River and were not contaminated by the plume cloud or the other accidents (Degteva, 1991). The second control group consisted of all people in the Chelyabinsk rural province but not living in the contaminated city of Chelyabinsk or the irradiated area surrounding Chelyabinsk (Kosenko, 1991). The control groups within the nonradioactive portions of the Chelyabinsk province consisted of 1.5 million people (Kosenko, 1991). This data base has been a part of the ongoing research for 40 years (Degteva, 1991). The information we obtained is a summary compiled from 33 years of data (Akleev, 1991). [NOTE: There are still 7 years of untapped data because the analysis is 7 years behind due to a lack of computer equipment.]

IMPACT OF IONIZING RADIATION ACCIDENTS

Statistical results showed significantly increased death rates along the Techa River over the last 33 years. Coefficients were described in terms of excessive risk per Gy. Findings showed stomach cancers to be two to three times greater than in survivors of Nagasaki and Hiroshima, breast cancer two

times greater, and lung and esophageal cancers two to three times greater (Degteva, 1991). Research is in progress that examines the progeny of irradiated mothers for stillborn children, abortions, and miscarriages. Analyses thus far indicate a significantly greater number of birthing complications in the irradiated mothers than existed among the control groups (Degteva, 1991). Today, near the Kyshtym reservation, where the town of Kasli used to be, the soil still contains from 1000 to 2000 Ci/km² of ⁹⁰Sr (Medvedev, 1991). It was from this area that 1,154 previous residents of Kasli were rapidly evacuated in a 7-10 day period following the accident. Several types of military training maneuvers are conducted in these contaminated areas today (Douplenski, 1991).

In addition to the ionizing radiation doses the victims of these three radiation accidents received, no humanitarian support existed, the people lived on a less than a well-balanced diet, and there was a pervasive lack of medical attention and equipment (Degteva, 1991). There were and still are only 50 beds to care for the 500,000 irradiated people from the three accidents (Kosenko, 1991).

Russian Ministry of Health officials in the Chelyabinsk Branch Office would like AFRRI as a research partner to perform some collaborative research (Kosenko, 1991). They perceive AFRRI as being able to assist them in increasing the accuracy of their dosimetry and in the creation of an interactive computer register. An increased knowledge regarding the late effects of ionizing radiation would result from this collaborative effort.

Specifically, this would assist in determining the: 1) long-term, 2) low-dose, 3) immunologic, and 4) genetic alterations associated with exposure to ionizing radiations (Akleev, 1991). It would also provide insight regarding the effects that exposure to ionizing radiation has on subsequent generations (child birth, miscarriages, abortions, etc.).

PSYCHOLOGICAL ASPECTS OF NUCLEAR ACCIDENTS

It is noteworthy that people living in the Kyshtym/Chelyabinsk area are very antinuclear as evidenced by the voluntary shutdown of two nuclear electrical generation reactors during June-July 1989 (Akleev, 1991; Medvedev, 1991). Also, although billions of rubles (equivalent to millions of U.S. dollars) had been spent on the construction of a breeder reactor, it too was shut down approximately 3 years ago, an aftermath of the Chernobyl accident in 1986 (Douplenski, 1991; Medvedev, 1991). The reason given for shutting down both of these "nuclear" facilities after years of use and construction was the psychological animosity that existed in the people living in this contaminated region (Douplenski, 1991). A similar psychologically induced result occurred in Moscow, where a new, ready to be used nuclear power plant was prevented from opening due to public outcry (Douplenski, 1991). In addition, a nuclear power plant approximately 40 km south of St. Petersburg was closed to appease the psychologically upset populace (Karpov, 1991). The impact that individual perceptions of ionizing radiation have on society is now being realized (IAEA Report, 1991).

In other parts of the FSU, specifically around the contaminated Chernobyl region, 35,000 people in the Belorus city of Gomel went on strike on 26 April 1991 to protest the fourth anniversary of Chernobyl. Similarly, 60,000 people waving "nationalist" flags packed the square in front of the Sofia Cathedral in Kiev, the capital of the Ukraine, and demanded punishment for those responsible for the world's worst nuclear accident (Bohlen, 1987, Reuters, 1990). The Rukh press agency reported similar antinuclear demonstrations in Kiev, the western Ukrainian city of Lvov, and in the Belorus city of Minsk, as well as demonstrations elsewhere in the two republics that were the worst hit by fallout from the accident (Reuters, 1990).

Reasons for the psychological outcry among the Chernobyl victims are numerous. The delays caused by scientific and political discussions finally resulted in the evacuation of 40,000 residents from an area where the contamination was 40 Ci/km^2 . Furthermore, 10,000 people receiving $15\text{-}20 \text{ Ci/km}^2$ and 60,000 people receiving $5\text{-}15 \text{ Ci/km}^2$ were not allowed to relocate (Kedrovsky, 1991). In addition, as part of the Chernobyl cleanup effort, numerous people are employed in 2 week (on/off) shifts inside the 6 km "Hot Zone" (Shishchits, 1991). It is expected that the rate of thyroid cancer is 5 to 10 times the rate expected for 1.5 million Soviet citizens, leukemia rates among children in some areas of the Ukraine are 2 to 4 times normal levels, and the death rate for people working in the Chernobyl plant since the accident is 10 times what it was before the accident (Barringer, 1990). Furthermore, the scientific director of the zone surrounding the damaged

Chernobyl power station estimated that the disaster has currently claimed over 7,000 lives (Wise, 1991).

Perhaps the worst aspect of these nuclear accidents is the omnipresent invisible threat and the continuing fear that the future is marred by irreversible cancer or genetic defects. This may have increased since the accidents, when radioactive fallout contaminated the environment, animals, and people. An undeniable and continual reminder for the residents is that all the timber in the affected areas is radioactively contaminated and cannot be used for furniture, for construction, or even for firewood (Matukousky, 1990).

In addition to the forests, the waters of the Pripyat, Sozh, Nevsich, Iput, Besyoad, Braginka, Kolpita, and Pokot Rivers are carrying radioactive silt into the Dnepr River. The entire grid of power stations on the Dnepr River down to the Black Sea is threatened with 60 million tons of radioactive silt, as are the 60 million people in these regions.

The anticipatory stress of these people is readily apparent and can be easily understood. Interestingly, according to an assessment by 200 scientists from 25 countries and 7 multinational organizations done for the United Nations International Atomic Energy Agency; stress-related illnesses are caused by lack of public information about the disaster and the mass evacuations that follow (I.A.E.A., 1991). In sum, the psychological stress that followed in the surrounding areas outside the radioactive hot zones was

"wholly disproportionate to the biological significance of the radioactive contamination" (I.A.E.A., 1991).

Even when no radiation is released from a nuclear accident, but only threatens, as was the case at Three Mile Island, the Kemeny Commission and other documents (Collins, 1984; Collins, 1991; Davidson, 1982, I.A.E.A., 1991) concluded that mental stress would be the main effect. The psychological findings could be criticized if used alone, for their potential self-serving function. To avoid this perception, neurochemical analyses that measured individual stress values were employed (Collins, 1983; Collins, 1991; Davidson, 1983). By using this multidisciplinary approach, we further clarified the adverse effects that exposure, or potential exposure to ionizing radiation has on humans. Consequently, since increased stress and associated behavioral alterations occur from anticipation as occurred at TMI; when actual exposure and deaths occur from radiation, the psychological and behavioral actions of the FSU residents are easily understood.

Consequently, the situation in the FSU is likely to become of major concern in future years as the future of 60 million people is adversely affected by the Chernobyl accident, and another million people (+/-) are adversely affected by the three accidents in the Kyshtym and Chelyabinsk areas. The psychological, physiological and epidemiological implications of these disasters require further study.

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A D D E N U M 1

During the course of these conversations at AFRI, Professor Valery N. Soyfer, Chairman of the Laboratory of Molecular Genetics at George Mason University, Fairfax, VA, and a recent defector from the Soviet Union, said, "The Soviet Union was the first nation to develop the hydrogen bomb." He then looked at me and said, "I bet you didn't know that, but we were." So I said, "Well can you tell me about that?" and he said he couldn't say any more on that topic.

A D D E N D U M 2

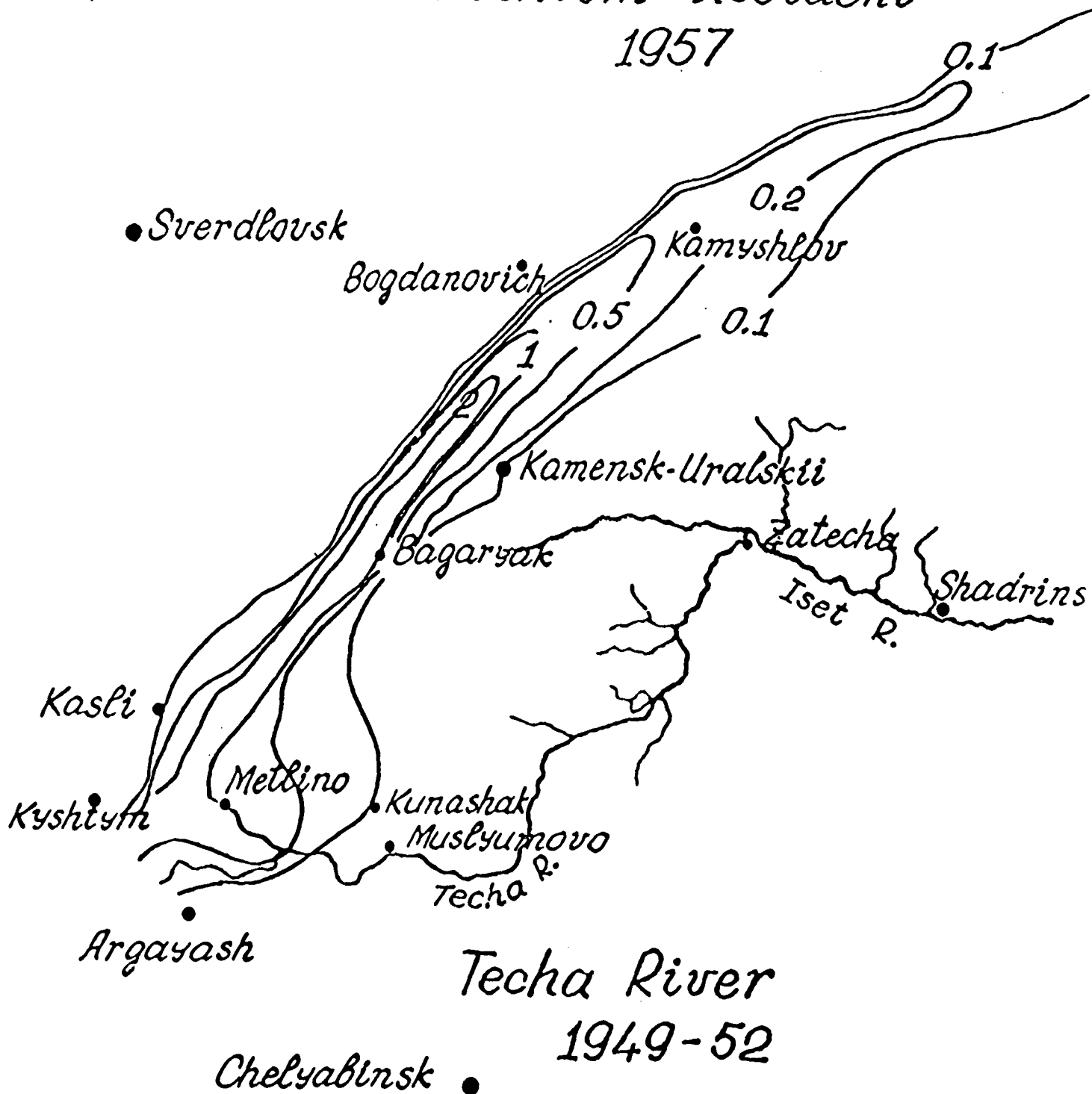
Dr. Alexander V. Akleev, Institute of Biophysics, U.S.S.R. Ministry of Health, Chelyabinsk Branch Office, summarized their research areas. They have been looking for a radioprotective drug for the last 15 years, but have not found anything that has worked. This unsuccessful effort involved looking at spleen extracts, compounds in herbs with low molecular weights, and peptides to defuse through the cell membrane. Reactor operators have been irradiated since they began their research back in the 1948-1950. The Institute is interested in late effects of low and medium doses; low doses are defined as 20 rads or less, and medium doses are 20 rads or greater.

NORTH



FIGURE 1

Kyshtym Accident 1957



Techa River 1949-52

0 10 20 30 40 50

LEGEND in Miles