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M-X/MPS

ENVIRONMENTAL
TECHNICAL REPORT

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DEPARTMENT OF THE AIR FORCE

**ENVIRONMENTAL CHARACTERISTICS
OF ALTERNATIVE DESIGNATED
DEPLOYMENT AREAS:
PUBLIC HEALTH CONCERNS**

Prepared for
**United States Air Force
Ballistic Missile Office
Norton Air Force Base, California**

By
**Henningson, Durham & Richardson, Inc.
Santa Barbara, California**

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2 October 1981

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OFFICE OF THE ASSISTANT SECRETARY


Federal, State and Local Agencies

On October 2, 1981, the President announced his decision to complete production of the M-X missile, but cancelled the M-X Multiple Protective Shelter (MPS) basing system. The Air Force was, at the time of these decisions, working to prepare a Final Environmental Impact Statement (FEIS) for the MPS site selection process. These efforts have been terminated and the Air Force no longer intends to file a FEIS for the MPS system. However, the attached preliminary FEIS captures the environmental data and analysis in the document that was nearing completion when the President decided to deploy the system in a different manner.

The preliminary FEIS and associated technical reports represent an intensive effort at resource planning and development that may be of significant value to state and local agencies involved in future planning efforts in the study area. Therefore, in response to requests for environmental technical data from the Congress, federal agencies and the states involved, we have published limited copies of the document for their use. Other interested parties may obtain copies by contacting:

National Technical Information Service
United States Department of Commerce
5285 Port Royal Road
Springfield, Virginia 22161
Telephone: (703) 487-4650

Sincerely,


JAMES F. BOATRIGHT
Deputy Assistant Secretary
of the Air Force (Installations)

1 Attachment
Preliminary FEIS

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1.0 INTRODUCTION

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This report examines certain health-related issues as to whether construction activities related to M-X deployment would result in significant hazards to human health. The issues addressed were identified during scoping meetings (1980) and the public comment period (Spring 1981). The potential health hazard posed by ambient radiation, specifically resuspended fallout material from past nuclear testing and the decay of naturally occurring radium, is analysed in the first section. Potential health risks associated with exposure to fibrous forms of indigenous zeolite minerals are examined in Section II. The risk associated with human exposure to spores of Coccidioides immitis, a fungus which is endemic to the potential M-X deployment area, is analysed in the third section. Recommendations and specific mitigative measures presented reflect a commitment to protect the health of both M-X and non-M-X populations from identifiable risks associated with M-X deployment.

2.0 RADIOACTIVE HAZARDS

2.1 BIOLOGICAL EFFECTS OF LONG-TERM HAZARDS FROM RADIOACTIVE FALLOUT

The public health significance of radiation is related to cellular damage incurred as a result of radiation exposure. The principal effects of ionization on human health are manifested in two forms:

- (1) Somatic damage
- (2) Genetic damage.

Somatic effects i.e., changes in cellular composition, structure or function may result from acute heavy doses of ionizing radiation, or they may be precipitated by chronic exposures occurring over a period of time. The specific effects of such exposures, either chronic or acute, are directly dependent on the total radiation dose. Genetic effects result from the alteration of the mutation rate of genes which are carried by man's reproductive cells.

The harmful effects of radiation are caused by ionization produced in the cells of living tissue and are dependent on both the nature of radiation and the energy absorbed. Internal radiation hazards are related to the mechanism of entry of radioactive material into the body. Such mechanisms include:

- o The breathing of radioactive material
- o The ingestion of contaminated food and water
- o Absorption through the skin
- o Entry through cuts or abrasions.

Exposure to external radiation is dependent on distance from the source, effectiveness of shielding, and duration of the exposure.

Ionization and excitation due to radiation can change and even destroy some of the cellular constituents that are essential for normal functioning. By-products may be formed which can act as toxic agents. Chromosomes may be broken, nucleic acid and/or cellular swelling may develop, the characteristics of cellular fluid may be changed, and the permeability of cell membranes may be increased. Cells may be completely destroyed, or their ability to undergo mitosis may be retarded or eliminated.

The biological effects of ionizing radiation generally result from acute or chronic exposure. An acute exposure occurs when the total radiation dose is received in a well-defined, relatively short period of time. A 24-hour exposure is characterized as "acute." The primary distinction between the effects of acute and chronic exposure is due to the fact that the body is capable of achieving partial recovery from many of the consequences of exposure, provided that the dose is small and/or spread out over a long period of time. If a certain dose of radioactivity

is experienced all at once, the consequences might be large, whereas if the same total dose were to be experienced over a period of ten years, the consequences might be a fraction of this, or even nonobservable. This is of particular relevance to the development of acceptable exposure limitations.

Different portions of the body exhibit greater and lesser susceptibilities to damage by radiation, which, when combined with differences exhibited between individuals, makes it difficult to predict the nature and extent of damage. The most radiosensitive cells appear to be those of the lymphoid system, bone marrow, spleen, organs of reproduction, and gastrointestinal tract. The skin, lungs, and liver are of intermediate sensitivity, while muscle, nerve, and adult bone cells are the least sensitive.

Radioactive fallout is the phenomenon whereby particles contaminated with radioactive materials descend to the earth's surface. Fallout, for all practical purposes, results only from nuclear explosions. Early fallout is that which reaches the ground within the first 24 hours after a nuclear event. Delayed fallout, consisting most commonly of smaller particles previously suspended in the troposphere and atmosphere, reaches the earth's surface over an extended period of time. Precipitation is a major factor influencing the amount and location of delayed fallout. Areas of high precipitation experience a relatively higher level of delayed fallout than their more arid counterparts. Once on the surface, delayed fallout may penetrate the soil or be subject to redistribution by air turbulence and other factors resulting in soil disturbance. Most of the particulate fallout remains in the upper few inches of the soil profile, and is therefore vulnerable to redistribution.

The most significant radioactive isotopes contained in fallout are cesium-137 and strontium-90. Because both of these isotopes are abundant among fission products and have relatively long half-lives, they constitute a large percentage of any delayed fallout. Plutonium-239, with a half-life of approximately 24,000 years, is the principal radioactive isotope in some nuclear weapons and may be a significant component of radioactive fallout.

2.2 CESIUM-137

Cesium-137 has a half-life of 30 years. In fallout older than one year, it is the principal constituent whose radioactive decay is accompanied by the emission of gamma rays. Cesium-137 also emits beta radiation. Cesium is relatively rare in nature, and the human body usually contains only small traces. Studies indicate that cesium is rapidly distributed in fairly uniform fashion throughout the body. Muscle tissue experiences a slight preferential deposition relative to the lungs and skeleton. The biological half-life of cesium in human adults ranges from 50 to 200 days, and is affected by diet, age, sex, race, and body weight. Because of its uniform distribution both beta and gamma cesium irradiation occur more or less uniformly throughout the body. The potential for biological hazard is reduced by cesium's relatively short biological half-life and its lack of concentration in any particular tissue.

The most likely mode of entry for cesium fallout particles is by ingestion. Foods containing a high level of cesium will be those most likely to present a hazard. Cesium enters the food chain through the soil or deposition on plant tissue. The relative cesium concentrations in foods reflect their positions in the food chain.

Only a fraction of that which is concentrated in and on plants will become fixed in the tissue and passed on to plant-eating animals. People ingesting meat would accumulate only a small fraction of the cesium in animal foods.

2.3 STRONTIUM-90

Strontium-90 has a half-life of approximately 30 years. It is a significant component of fission products and represents a considerable fraction of the radioactive fallout products which are several years old or more. Strontium, and its decay products emit beta particles which can cause serious localized damage following deposition and retention in the skeleton. Animal tests with internalized strontium indicate that the pathological effects which may result include bone necrosis, bone tumors, leukemia, and other hematologic abnormalities. As with other isotopes contained in delayed fallout, precipitation is the dominant mode of deposition on the earth's surface. The standard mode of entry into the human body is by ingestion of contaminated animal and plant foods.

2.4 PLUTONIUM-239

Plutonium-239 is the major radioactive fuel in most nuclear weapons, and is sometimes found in delayed fallout. It exhibits a radioactive half-life of 24,000 years as well as a long biological half-life in the skeleton (approximately 100 years) and the liver (40 years). Continuous long-term exposure of a localized part of the body can cause serious problems. Plutonium is primarily a hazard when inhaled. In addition to its radioactivity, plutonium also acts as a systemic poison. However, "...the quantity of plutonium compounds found in the fallout that must be ingested in order to be potentially poisonous are so large that it is not considered to be of primary concern compared with other constituents of nuclear weapon debris." (Glasstone and Dolan, 1977; P.601)

2.5 M-X CONSTRUCTION AND RADIOACTIVITY HAZARD

Serious concern was expressed during the public comment period that M-X-related construction activities might unacceptably expose residents and workers to hazardous radioactive particles generated from two primary sources:

- (1) nuclear warheads and the simulators and
- (2) radioactive particles deposited in the Great Basin as a result of the above ground nuclear testing program, which might become resuspended during construction activities.

The issue of radioactivity associated with the former is discussed in Chapter 1 of the FEIS. The latter issue will be reviewed here. The specific concern in the M-X construction area is the potentially harmful inhalation of radioactively contaminated dust or ingestion of contaminated food.

2.6 SOURCES OF RADIOACTIVITY

Radioactivity in the region of proposed M-X deployment is derived from three sources:

- (1) naturally occurring ionizing radiation associated with cosmic rays and soils

- (2) fallout from atmospheric nuclear tests conducted by foreign countries
- (3) fallout from nuclear weapons tests in Nevada.

2.7 COSMIC RADIATION

Ionizing radiation associated from cosmic rays represents a recognized public health concern which has the attention of the world health community. However, exposures associated with M-X construction are no different from that which the general population receives and does not warrant further discussion in connection with M-X.

2.8 RADON

Natural radioactivity is also generated by the decay of certain physical components of the earth's crust such as radium, uranium, and their radioactive daughters. The amount of ambient radioactivity resulting from these sources is related to their half-lives and the environmental conditions to which they are exposed. Local concentrations depend upon local deposition and surface conditions affecting dilution and dispersion. Radon, a radioactive decay product of Radium-226 which occurs naturally in the area's soil, is released into the atmosphere constantly. Radon-222 is the heaviest of the noble gases, with a density 7.7 times that of air. One curie of its parent, radium-226, produces about 2×10^6 Ci of radon per second. Radium-226 concentrations in soils and rocks are approximately 1×10^{-12} Ci/g. Therefore, on the average, each gram of the surface layer of soil is a potential source of some 2×10^{-18} Ci of radon per second. Radon and its daughters constitute a large portion of the naturally occurring background radioactivity in the lower altitudes. Their concentrations vary diurnally and seasonally depending on meteorological conditions. Generally, radon concentrations in ground level outdoor air are on the order of 0.1×10^{-12} Ci/liter with a normal range of $0.04-0.4 \times 10^{-12}$ Ci/liter.

Radon is an inert gas with a half-life of 3.82 days. Therefore, some of the radon may escape from the soil particles and migrate to the surface without being impeded. The rate of radon emanation from undisturbed soil to air is a complex function of the nature of the soil, vegetative cover, and meteorological conditions. The average rate of radon emanation from earth's surface is about 0.5×10^{-12} Ci/sq m-sec.

Both natural processes and human activities contribute to radon concentrations in air. Large-scale earth moving and deep channeling cause accelerated release of radon from rocks and soils. The rate of emanation depends on the mineral, soil and rock characteristics such as porosity and permeability, the size of particles in which the radon is incorporated, the degree of weathering of the rock, and the richness (in radium) of the soil and rock. A high rate of radon release may occur in the immediate vicinity of the working environment for trench diggers and heavy machine operators during construction of M-X operating bases and shelters.

Meteorological conditions have a controlling effect on radon concentrations. Meteorology affects not only the amount of mixing and dilution but also the rate of emanation from the surface. Excessive concentrations are rapidly diluted by adequate ventilation.

The desert environments of Nevada and Utah are characterized by high solar radiation, low humidity and precipitation, and high wind. These factors all tend to enhance emanation and thus, potential exposure to radon. In contrast, surfaces of parent rock in deployment areas are steep, rough and relatively free from attack by rain and vegetation. Sparse vegetation fails to reduce wind effects, or retain surface layers. These factors combine to reduce radon concentrations because of increased atmospheric dilution.

Since the radon flux is elevated in arid climates with dry surface soil conditions and sparse vegetation and with the richness of radioactive ores in the soil, it can be anticipated that in some specific M-X construction sites radon flux would be higher than the national average. Federal standards for radon-related exposure are 4 man work levels per year or 0.3 work levels per month. (Archer, 1981) (Note: The unit, Man work levels per year, refers to the amount of exposure to radioactive materials experienced at the rate of 40 hours per week for 13 weeks.)

2.9 FALLOUT AND RESUSPENDED DUST

Radioactive fallout from atmospheric nuclear weapons tests, whether conducted in Nevada or elsewhere in the world, displays similar characteristics. Some differences relevant here are the relative quantities of plutonium and differences in the amounts and locations of fallout.

Fallout resulting from past atmospheric nuclear weapon tests in Nevada contributed fission products to the worldwide fallout inventory. Also, larger particles, which fall more rapidly, have been deposited on the surface down-wind of the explosion. Atmospheric weapon tests were generally conducted when the wind was to the northeast, and no rain was forecast in the vicinity. Consequently, the local fallout typically occurred to the northeast of the test site when there was no precipitation to affect the deposition.

In Nevada, in addition to nuclear weapon explosions, a series of tests were conducted in which plutonium was released by chemical explosions. The fallout from these tests was somewhat different from that of nuclear explosions. Its different mixture of isotopes permits its identification. Distribution and location have been studied extensively.

The principal fallout concern in the M-X construction area is for inhalation of radioactive material or its ingestion with food. Strontium and cesium intake results primarily from ingestion of food containing these elements. Plutonium intake, on the other hand, primarily results from inhalation.

DISTRIBUTION OF RADIOACTIVITY (2.9.1)

When radioactive debris has been deposited on the surface of the earth, its subsequent location is affected by a variety of natural forces (Pendleton, 1981; Miller, 1980; Beck, 1980). Material on the surface can be eroded by wind or water and moved to new locations. The amount of redistribution is a function not only of

amounts of wind and rain, but also of the terrain and the nature of the soils. These actions in the Nevada/Utah area cause fallout materials to be distributed exponentially in depth, with most in the top few inches of soil, and nearly all in the top ten inches. In the drier areas with sparse vegetation, windblown sand collected around plants is normally higher in radioactivity than the surrounding areas which have been wind-scoured. In areas where rainfall is deposited primarily in periods of short duration but high intensity, surface runoff with accompanying erosion could result in concentrations of fallout materials in drainage channels, and in areas where the water velocity is low. The peak radioactivity in such locations has been estimated to exceed the average in a region by up to a factor of 25 (Pendleton, 1981).

Radioactive aerosols are normally found in the air near the earth's surface. These consist both of long-term fallout which has not yet been deposited on the earth, and of particles which were resuspended by wind (Anspaugh et al., 1975). The quantity of radioactive material resuspended is dependent on a variety of factors such as the soil particle size, the particle cohesiveness, surface roughness, and wind velocity. Also, actions which mechanically disturb the surface and create turbulence will increase the amount of resuspended radioactivity.

REPRESENTATIVE VALUES (2.9.2)

In Nevada and Utah, the average radiation levels due to gamma rays from ambient sources vary from about 9 to 20×10^{-6} R/hr (Miller, 1980, Table 2). Most of this is due to cosmic rays and natural radioactivity, between 0.5 and 3.5 percent coming from radioactive fallout, primarily cesium 137. Typical quantities of cesium 137 found in the Nevada/Utah area soils in 1979-1980 vary from about 20 to 150 mCi/sq km (Miller et al., 1980; Beck et al., 1980). Strontium-90 levels should be about two-thirds those for cesium. Levels for plutonium 239 in the area of M-X interest have been measured as typically 2 to 9 mCi/sq km, with some isolated locations near 100 mCi/sq km, (Bliss et al., 1976) and reflected in Figures 1 and 2 (Hardy, 1976).

Representative quantities of airborne materials are more variable, both because measurements are more complex, and that which is currently observed is primarily due to worldwide fallout, which changes in time. The materials currently observed are attributed primarily to the nuclear tests conducted by the People's Republic of China in 1978 (Potter et al., 1980). Representative upper values for airborne cesium 137 in 1979 were from 2 to 4×10^{-14} Ci/cu m (EPA, 1979; Potter et al., 1980). In 1978, values approximately twice as high were observed. Measurements of suspended plutonium ranged from 0.02 to 0.5×10^{-15} Ci/cu m in 1972-1973, and from 0.01 to 0.1×10^{-15} Ci/cu m in 1978-79.

2.10 M-X CONSTRUCTION EFFECTS ON RADIATION

Fallout materials typically are located within the top few inches of soil, with the concentration decreasing rapidly with depth. Under these circumstances, construction activities of excavation or grading which disturb the top few inches would cause redistribution of old fallout. Activities affecting deeper soil would bring uncontaminated soil to the surface resulting in dilution or shielding of the surface layers.

To approximate the hazard due to radioactive dust, one should examine several classes of construction activity, estimating the quantity of dust and the level of

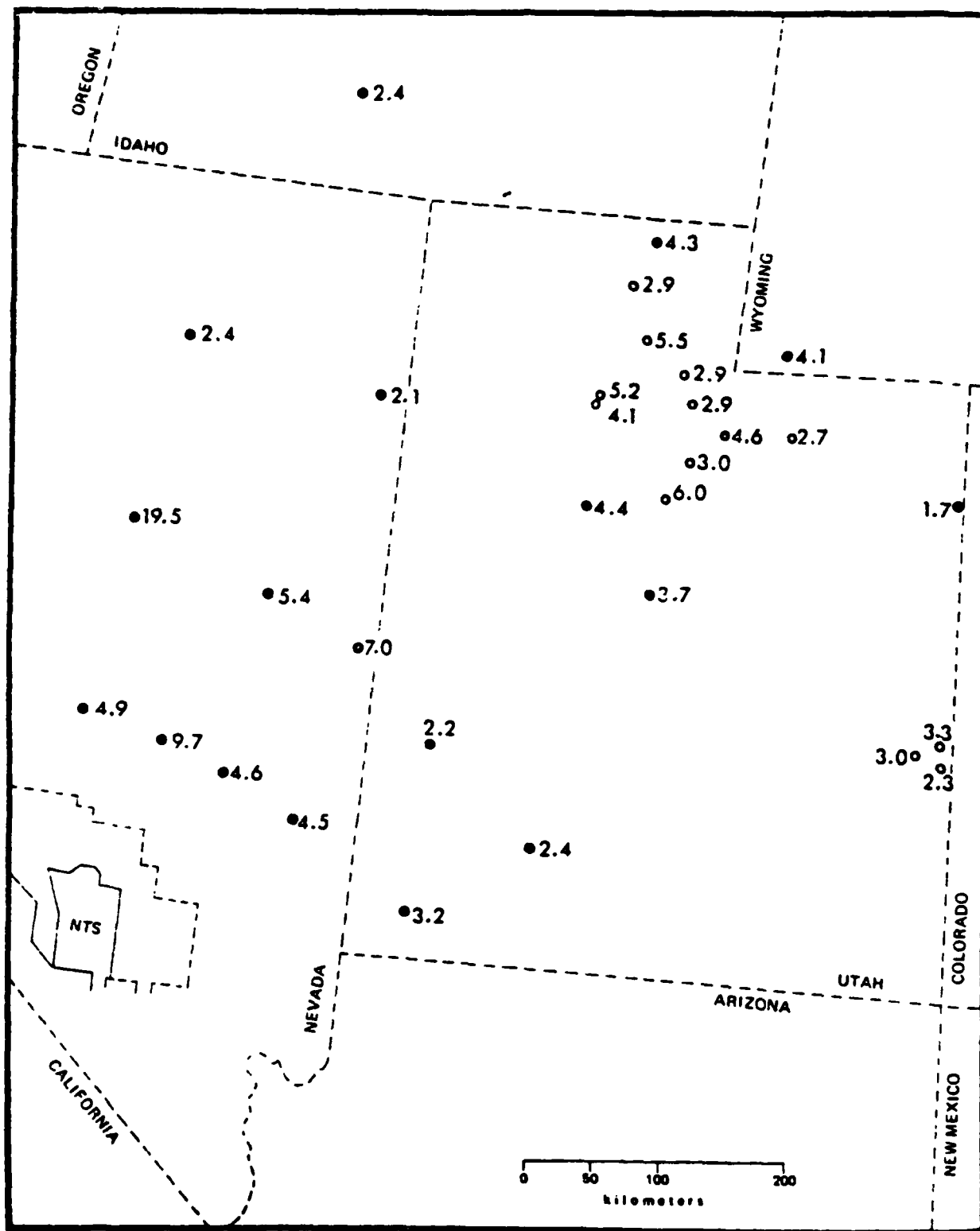


FIG. 1 CUMULATIVE TOTAL DEPOSIT OF Pu-239,240
(mCi per km²)

4197-A

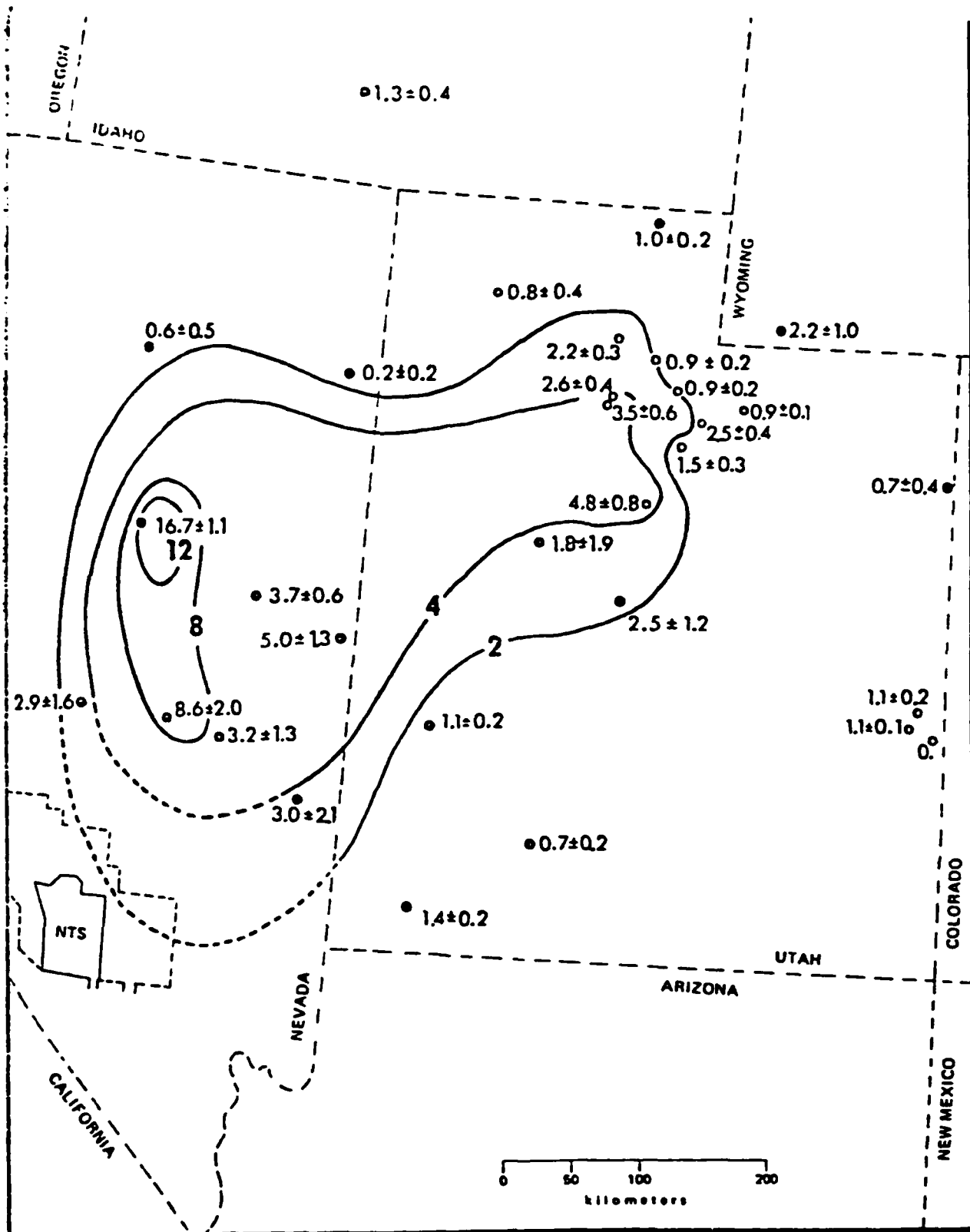


FIG. 2 CUMULATIVE NTS DEPOSIT OF Pu-239,240
(mCi per km²)

4198-A

artificial radioactivity to be expected. The results will then be compared with known existing radioactive hazards.

The amount of dust generated, and the region of the soil from which it comes, differs for various activities. For example, deep excavation primarily affects parts of the soil which contain no debris. On the other hand, grading virgin soil, or driving over undisturbed surfaces will typically involve larger quantities of soil with high specific activity. Calculations of dust density resulting from M-X construction in ETR-13 indicate that dust levels approaching 1000×10^{-6} g/cu m are predicted in the vicinity of active construction sites, while 24-hour averages near 100×10^{-6} g/cu m can occur in the general area.

For an upper estimate of the radioactivity carried in dust, we assume that all of the dust generated contains radioactive material at the peak levels measured in the upper soil layers. Clearly this estimate represents an extreme. First, the amount of radioactivity deposited in the soil at an average location is considerably less than the peak values assumed. For this reason alone, we expect that the estimates are high by about a factor of ten.

Second, as discussed earlier, the radioactive material is normally contained in a few inches of soil; our assumption that all the soil affected by construction has radioactivity equal to the maximum local density means that the quantity of material actually present is 1/2 to 1/10 of that used in the estimates.

Factors which would tend to increase the estimated suspended radioactivity would include local deposits greater than the upper value used, aspects of construction which selectively convert the radioactive-rich layers into fugitive suspended dust, and quantities of suspended dust greater than those calculated.

Data from Table 2 of Beck et al., (1980), present the radioactivity due to cesium 137 in the upper layers of the soil. For example, a representative high level of radioactivity in the area is at Moab, Utah, where it, in the top inch of soil, is given as 1.9×10^{-12} Ci/g of soil. Multiplying by 100×10^{-6} g/cu m gives a value of approximately 1.9×10^{-16} g/cu m for the maximum estimated airborne cesium radioactivity resulting from M-X construction.

To put this level of activity in context, compare data obtained on the ambient airborne levels of radioactivity due to cesium-137 at representative sites. From Table B-1, pages 65-67, Potter et al., (1980), we see a maximum value of 8.5×10^{-14} Ci/cu m at St. George, Utah, while average values in the area are less than 0.1×10^{-14} . The expected average airborne radioactivity is about one hundred times less than the peak ambient airborne levels, and a factor of five less than the average measured ambient. A detailed evaluation of the potential hazard due to cesium and strontium has not been made. However, it appears that for cesium, and almost certainly for strontium as well, the additional airborne radioactivity resulting from M-X construction is relatively small, and probably does not constitute a significant hazard.

Plutonium previously deposited on soils in the proposed M-X construction area has been extensively measured. At isolated locations peak values are near

100×10^{-9} Ci/sq m, while most locations measure far less. Assuming that all this plutonium is located in a layer 5 cm thick, then in soil of nominal density we find the maximum specific activity to be 7.7×10^{-13} Ci/g of soil.

For an estimate of the maximum expected plutonium carried in dust, we assume that all of the dust generated contains plutonium at the specific activity of the soils indicated above. Then we find that the dust carried 0.77×10^{-16} Ci/cu m of air, for the average construction dust level of 100×10^{-6} g/cu m.

The ambient levels of plutonium present in the air have been routinely measured at a number of locations in the United States, with emphasis on the Nevada/Utah region. The suspended plutonium measured at present is attributed to worldwide fallout. Typically, the measured amount of airborne fallout fluctuates quite widely because of the complex meteorological factors affecting its motion. During 1978-79, the highest Pu concentrations obtained were approximately 1.0×10^{-16} Ci/cu m (Potter et al., 1980).

There are a variety of standards promulgated for allowable atmospheric concentration of plutonium, the most stringent for general uncontrolled public access being 2×10^{-14} Ci/cu m.

2.11 HAZARD ANALYSIS

Maximum dust in the immediate vicinity of construction activity could reach very high values, but at levels much above $1,000 \times 10^{-6}$ g/cu m, respiration without a filter would be difficult. In both the local peak and the long-term average, increasing by a factor of two would appear to present upper limits.

The various factors discussed previously and their potential impact on isotope density are:

Average deposit x 1/10
Nonuniform density x 1/2 to 1/10
Wind and water erosion x 2.5
Fugitive dust x 2

Multiplying our estimates by the first two factors gives a more realistic estimate of the nominal value of dust exposure. Multiplying by the last two factors should give an upper limit which may be found in a few small areas.

Table 1.1.2.6-1, summarizes airborne concentration levels of cesium and plutonium in fugitive dust. The maximum expected values of plutonium activity are seen to be of the same order of magnitude as observed peak ambient values. However, the maximum expected during peak construction amounts to less than 4 percent of the federal standards. Our estimate of an upper limit amounts to 20 percent of the federal standard.

The estimates in the table show that the specific activity expected from suspended cesium during average construction is less than the nominal ambient value, and is less than the peak ambient value even during the upper limit estimate for peak construction activity. Consequently, we do not expect that M-X construction significantly changes the potential hazard from cesium (or strontium)

Table 1.1.2.6-1. Specific activity suspended as dust in units of 10^{-16} ci/cu m.

	Peak ¹ Construction	Average ¹ Construction	Ambient ² 1978-1979	Federal Permissible Exposure
Plutonium:				
Maximum Expected	7.7	0.77	1	200
Nominal Value	0.39	0.039	0.25	200
Upper Limit	39	3.9	N/A	200
Cesium:				
Maximum Expected	19	1.9	800	N/A ³
Nominal Value	0.95	0.095	10	N/A
Upper Limit	95	9.5	N/A	N/A

T5380/10-2-81/a

¹ Incremental contributions due to construction activity:

Peak construction activity suspended dust = 1 milligram/cu m;

Average construction activity suspended dust = 1/10 milligram/cu m.

² Ambient values arise primarily from worldwide fallout (EPA, Nuclear Radiation Assessment Division, 1980).

³ Data not available.

presently in the atmosphere. Note that federal standards defining allowable exposure levels for radioactive particles are developed to reflect cumulative impacts associated with exposure that occur over time.

The upper limit of activity expected from plutonium during average construction is of the same order of magnitude as the maximum ambient values. During peak construction, activity from suspended plutonium may exceed the ambient values. Even so, they remain far less than the permissible exposure levels.

A direct estimate, using Cohen's Formula, can be made of the hazard from inhalation of suspended plutonium.

The average adult inhales about 7,300 cu m of air per year. Multiplying by the specific activity of plutonium suspended in dust, and the number of grams of plutonium 239 per Curie, yields the amount of plutonium inhaled in a year. Cohen estimates that $1,300 \times 10^{-6}$ g of plutonium-239 inhaled is the nominal cancer-causing dose. Dividing this into the calculated total dose yields the expression below for the probability that an individual will contract fatal cancer from exposure to plutonium in construction dust. This expression is:

$$n \times A_s \times 9.9 \times 10^7$$

where: n is the number of years of exposure
 A_s is the specific activity of plutonium in the dust (Ci/cu m)

Using this relationship we find that the probability that an individual exposed 24 hours per day for one year to the maximum expected average construction dust will develop fatal cancer is 7.6×10^{-2} . In comparison, the lifetime probability of accidental death is about 6×10^{-2} .

2.12 CONCLUSION

On the basis of the evaluation to date, it appears that M-X construction activity in Nevada and Utah would not result in a significant radiation hazard to the general public.

The greatest potential for hazard exists in the immediate vicinity of heavy construction activity in the isolated regions of larger than normal plutonium deposits, or in trenching or excavating where concentrations of natural sources of radon exist.

Estimates are that the long-term exposures to plutonium are much less than federal standards allow, and indicate that negligible risk of cancer exists. Comparison of estimates with ambient values of suspended cesium leads to the conclusion that a small increase in ambient concentrations result and would not add significantly to the existing hazard from cesium or strontium in the atmosphere.

Measures to minimize this potential for hazard would include dust suppression during construction, limitations on construction activities during adverse meteorological conditions specifically in areas of concentrated deposition, and the use of respirators by personnel exposed to heavy dust.

3.0 FIBROUS ZEOLITIC MATERIALS AND HUMAN HEALTH

In recent years a controversy has emerged within the scientific community concerning the existing and/or potential negative impacts which fibrous zeolitic materials either have or could have on human health. Certain internationally known scientists have already implicated several types of zeolites, erionite and mordenite, as causative agents in the etiology of pleural mesothelioma. This malignant, usually fatal, form of lung cancer is relatively rare, causing an annual death rate of one to two individuals per million population. Because of morphological similarities between zeolitic and asbestos fibers, there is interest in the higher mortality rates among miners and industrial workers with lengthy exposures to asbestos. Those convinced that exposure to zeolite fibers is dangerous interpret controversial Turkish research linking zeolites and pleural mesothelioma as conclusively indicating the zeolite (Baris et al., 1975, 1976). Other scientists propose these alternative interpretations:

- (1) the Turkish data are in fact conclusive, but that the conclusion is that there is no correlation between zeolitic fibers and pleural mesothelioma, and,
- (2) the data are inconclusive and additional information is needed before the issue can be resolved.

Concern was expressed, both in the M-X scoping meetings and in the recently completed public comment period, that the proposed M-X construction activities in Nevada, an area with both known and suspected zeolite deposits, might result in the exposure of individuals to unnecessary and unacceptable health risks. The ultimate objective of this report is to examine the issue and to determine whether construction activities related to M-X deployment would pose an unacceptable hazard to human health. The emphasis here is on the issues underlying decision-making. For more information see ETR-11, Section 8.

3.1 ZEOLITES AND HUMAN HEALTH

The present controversy evolved from the relatively recent surfacing of a poorly researched class of minerals -- zeolites -- as potential carcinogenic agents. The speculative linking of the fibrous zeolite erionite with an abnormal incidence of pleural mesothelioma first appeared in the middle 1970s when Professor Baris and his colleagues reported on an abnormal incidence of the disease in two, small Turkish villages (Baris et al., 1975; Baris et al., 1975; Baris et al. 1976). Having identified fibrous material in the pleural tissue of one victim, Baris' group tentatively hypothesized that asbestos was the causative agent. Unable to verify this hypothesis, he presented his findings to the International Union Against Cancer in 1977. Later that year, a team of IUAC scientists conducted epidemiological reconnaissance in the area, subsequently verifying Baris' mesothelioma diagnoses. Through electron microscopy, rock and dust samples from the region revealed the presence of fibrous zeolitic materials and fibrous volcanic glass. (Elmes, 1977: pp 11-13). The findings of the IUAC study were presented to the Society for Occupational and Environmental Health in December 1977. Researchers Wagner and Pooley concluded that, on the basis of morphological similarities between the erionites found in the Turkish samples and the proven carcinogen crocidolite, a type of asbestos, the needleshaped zeolite could be the causative agent in the abnormal

disease distribution. Additional samples obtained in January 1978 confirmed the presence of zeolitic minerals in the volcanic bluffs surrounding the affected village streets and within dwellings constructed of the indigenous tuff.

Interest in the issue intensified as professional health workers and the press became aware of the potential implications and rushed to controversial conclusions. Recognizing the need for a more thorough analysis of the situation, the United States Geological Survey obtained the service of Dr. Frederick Mumpton to perform a preliminary study of the affected region in Turkey. His charge was to obtain reliable data on the zeolite content of the bedrock, building blocks, road dust, soils, etc. from both mesothelioma and nonmesothelioma villages in the study area. Mumpton's findings that (1) certain villages with similar exposure indexes exhibited no abnormal mesothelioma and (2) one village experienced pleural mesothelioma but had no identifiable zeolite presence, fueled the controversy originating from Baris' work. Based on this finding Mumpton emphatically stated:

"In so far as a positive correlation between the existence of erionite or other zeolites in the indigenous tuffs of these Turkish villages and the incidence of pleural mesothelioma, the data are equivocal and tend to suggest that no correlation exists."

He goes on to claim:

"It is therefore erroneous to state that zeolite minerals (and especially erionite) constitute an environmental health hazard capable of causing malignant disease or that these materials should be considered as 'possible' carcinogens." (USGS, 1979. P44)

In follow-up investigation during the summer of 1979, Mumpton confirmed his results reported in 79-954 (USGS, 1979); i.e., there is a negative correlation between observed zeolites -- particularly erionite -- and pleural mesothelioma.

The interpretations given to these sets of data are far from being similar. One interpretation is that the work of Baris and the IUAC, when viewed concurrently with the morphological similarities between zeolitic fiber and asbestos fibers, are sufficient to indict fibrous zeolites, particularly erionite, as being carcinogenic. The opposite interpretation, expressed by Malcolm Ross of the USGS, is that the work of Mumpton conclusively demonstrates that zeolites are not a major factor in the mesothelioma problem. He and others suspect that other factors such as genetic predisposition should be explored. And still another interpretation is that the existing data base is not sufficient to conclusively demonstrate either a positive or no correlation between exposure to fibrous zeolites and the development of pleural mesothelioma. Conflicting interpretations of the data and the resulting confusion in the minds of people working with and/or exposed to zeolite materials are evident.

3.2 ZEOLITES, HUMAN HEALTH, AND M-X CONSTRUCTION ACTIVITIES

Concern has been expressed about human exposure to fibrous zeolite material as a result of M-X-related construction activities. A representative of the Department of Health and Human Services expressed concern that M-X construction activities might result in the unacceptable exposure of individuals to "... a fibrous mineral similar to asbestos which when inhaled, can cause fibrosis and mesothelioma, an irreversible and untreatable form of lung cancer." Deposits of these fibrous minerals, zeolites, have been identified in the potential M-X deployment areas (Deffeyes, 1959). Erionite and mordenite are two varieties of fibrous zeolites which do occur in the volcanic soils of Nevada and Utah. The focus of the concern is the production of construction-related dust generated from zeolite containing soils and the suspension of potentially harmful fibrous materials which could result in unacceptable human exposure. A summarization of the available information is as follows:

3.3 EXISTING KNOWLEDGE

THE TURKISH RESEARCH (3.3.1)

- o There was a higher than normal incidence of pleural mesothelioma in the two Turkish villages as reported by Baris and the IUAC.
- o Laboratory examination revealed the presence of fibrous zeolitic (erionite) materials and fibrous glass in the rock and dust samples from the mesothelioma region.
- o There are morphological similarities between the erionite fibers found and the fibers of crocidolite and other asbestos minerals.
- o Similar fibers were found in similar samples taken from nearby villages which had not experienced an abnormal incidence of the disease.
- o Pleural mesothelioma was found in a village in which zeolite fibers were not present.

CARCINOGENIC PROPERTIES OF ZEOLITE FIBERS (3.3.2)

- o Laboratory experiments wherein large quantities of various fibers are implanted in the pleural tissue of animals indicate that it is not the specific chemical composition of the fibrous material which is of significance, but rather that carcinogenicity appears to be dependent upon the size, shape, and ability of the fiber to resist fragmentation when implanted in the tissue.
- More specifically, fibers of any kind with a length greater than five microns, having a diameter of one micron or less and resistant to fragmentation, are the ones which are most likely to represent serious health hazards if successfully implanted in pleural tissue.

- Particles smaller than the critical size tend to become trapped by macrophage and ultimately expelled from the system. Particles greater than 10 microns in length appear to be unsuccessful in penetrating to the inner reaches of the pleural cavity.

CARCINOGENIC PROPERTIES OF ASBESTOS FIBERS (3.3.3)

- o Only certain fibers (primarily, crocidolites) of a certain size have been proven to be carcinogenic.
- o The inhalation of airborne fibers is the critical mode of entry into the body.

ZEOLITES IN PROPOSED M-X DEPLOYMENT AREA (3.3.4)

- o Deposits of zeolitic materials, particularly erionite and mordenite have been identified within the area.
- o The zeolitic materials identified are of the fibrous type.
- o The specific locations of zeolitic deposits within the potential deployment area are not known.
- o "The occurrence of voluminous pyroclastic and volcanoclastic rocks in the M-X deployment area suggests that zeolites may also be very widespread" (ETR-11).

REPORTED INCIDENCE OF PLEURAL MESOTHELIOMA IN AREA (3.3.5)

- o A cursory review of health records does not reveal an abnormal incidence of pleural mesothelioma in the proposed Nevada/Utah deployment area.

CHARACTERISTICS OF M-X CONSTRUCTION ACTIVITIES (3.3.6)

- o They will undoubtedly generate dust to which localized exposure will be significant.
- o Some potential deployment areas are known to contain zeolitic materials.

FIBER TRANSPORT AND POTENTIAL HUMAN EXPOSURE (3.3.7)

- o Determination of the significance of any potential hazard associated with zeolite-containing dust should include an analysis of the tendency of zeolites to become airborne and the distribution of "critical size" particles in the soil and in the air. These data are necessary if realistic estimates of the potential dust hazard are to be developed.

3.4 UNRESOLVED ISSUES

- 1) Whether there is, in fact, a problem
- 2) Whether a correlation exists between the presence of zeolitic fibers in rock and dust samples from the Turkish study area and the verified high ratio of pleural mesothelioma found in the two villages
- 3) Whether all or any types and forms of fibrous zeolites are carcinogenic
- 4) Whether laboratory tests utilizing large doses of fibrous materials accurately reflect potential health hazards
- 5) Whether existing health records accurately depict the incidence of pleural mesothelioma. (Those claiming that the data are insufficient cite that accurate diagnosis of the disease is difficult. Furthermore, onset of the disease appears from 20 to 40 years following exposure to a pathogenic agent.)

In summary, the first and most important question remains unanswered: Is there sufficient information available to prove the existence of a correlation between fibrous zeolitic materials and pleural mesothelioma?

3.5 NEED FOR ADDITIONAL INFORMATION

There are indications that there may be a problem, but no definitive resolution exists. Resolution entails the undertaking of a preliminary research effort to determine whether there is a problem. A likely place to begin would be with an examination of disease incidence among highly exposed populations. An examination of the health statistics for American, Japanese, and Mexican miners of zeolite could, if the data were sufficiently detailed, shed light on the existence of such a problem. Concurrent analysis of dust and soil samples from the actual mining areas would yield, when correlated with specific activities, invaluable information on suspended particle characteristics and subsequent human exposure. The results of these efforts, when viewed in conjunction with existing field and laboratory data would help to evaluate the need for future research.

Should a need for significant investigation become apparent, it would only be effectively met through the implementation of a coordinated, interdisciplinary research effort addressing the following issues:

MINERALOGICAL (3.5.1)

- o Forms of zeolitic materials
- o Tendency of bulk materials to form particles of the "critical size"
- o Characteristics of fibers
- o Tendency of the fibers to become airborne

- o Relationships between the percent of zeolitic materials in the soil and their sizes relative to the percentage and concentration of fibers in airborne suspension.

GEOLOGICAL (3.5.2)

- o Identification and classification of zeolitic deposits and zeolite soils and the mapping of their distribution.

BIOMEDICAL (3.5.3)

- o Epidemiological investigations of incidence, prevalence, and mortality from mesothelioma among zeolite-exposed populations
- o Population and demographic analyses to identify populations with predisposing conditions
- o Studies of carcinogenicity of fibers of various varieties of zeolite and various morphological types
- o Determination of critical exposure and dosage thresholds.

The undertaking of such complete analyses presents a substantial commitment of financial, personnel, and time resources. It must be warranted by reliable data indicating that there is, in fact, a potential problem. There has not been assembled indisputable evidence indicating that there is, in fact, a potential health problem posed by exposure to fibrous zeolitic materials. Such a conclusion is speculative. There is, however, sufficient reason to be suspicious and to develop additional information.

3.6 CONCLUSION

M-X-related construction would generate substantial quantities of dust, at least part of which will be subject to transport by environmental conditions and result in human exposure to zeolites. There is no conclusive evidence linking zeolites to pleural mesothelioma. There are no data available which allow prediction of the concentrations of zeolites to which M-X workers would be exposed. These facts indicate that additional mitigative measures, beyond those already proposed for construction-related dust suppression, are not required at the present time.

Because of the indication of a potential zeolite-linked health problem among M-X workers, the Air Force will consider performing, or asking another agency to perform, a study of zeolite exposure and related epidemiological studies in the M-X construction area. This information would assist in evaluating the role of specific construction activities in the generation of zeolitic dust and in the determination as to whether fibers of critical size for potential carcinogenicity are formed.

3.7 MITIGATION

Because of the inconclusive nature of the zeolite issue, the Air Force Surgeon General will further evaluate the problem. This evaluation will be concluded prior

to commencement of major construction activity in zeolite regions. If the evaluation indicates that zeolites represent a significant health hazard, appropriate mitigation measures, such as dust suppression and respiratory protection, will be employed. In any case the Air Force will comply with any zeolite control measures that may be required by appropriate health authorities.

4.0 M-X ACTIVITIES AND COCCIDIOIDOMYCOSIS

PUBLIC COMMENT ON DRAFT EIS:

"It seems incumbent upon the Air Force to thoroughly examine this health hazard in this EIS, given the large amounts of land that will be disturbed by the M-X and the Air Force's statement of the Milestone II EIS document that 'Persons working in a situation in which they are exposed to dust are particularly liable to exposure to valley fever.' Toiyabe Chapter Sierra Club; Las Vegas, Nevada. (A0799-6-003)

Concern has been expressed that M-X construction activities may result in an unacceptable exposure of individuals to Coccidioides immitis spores with a resulting increase in the incidence of coccidioidomycosis. "Valley fever," as it is more commonly known, is a respiratory infection to which all mammals are susceptible. Human exposure may occur in the following ways:

- o through contact with the fungal spores via residency within or around an endemic area
- o contact with a contaminated product from an endemic area
- o previous physical presence in an endemic area, such as traveling through and
- o through laboratory exposure to the agent.

Both the symptomatic and the less common, but more serious, disseminated forms of the disease are common among individuals exposed to airborne spores generated by soil disturbing activities in endemic areas of Coccidioides immitis. There are indications that racial and sexual characteristics influence both the likelihood that an individual will, upon exposure, develop an infection and the ensuing severity of that infection.

The objective of this section is to determine whether or not M-X construction activities will have a significant probability of effectuating an increased incidence of coccidioidomycoses among construction workers and nearby residents.

4.1 EPIDEMIOLOGY OF COCCIDIOIDOMYCOSIS

NATURE OF INFECTION (4.1.1)

Coccidioidomycosis is initially a respiratory infection derived from exposure to airborne Coccidioides immitis spores.

MODE OF TRANSMISSION (4.1.2)

The airborne fungal agents are transmitted to the individual and exposed to pleural tissue through inhalation. The disease is not transmitted from man to man or from animal to animal.

Two forms of the disease occur: symptomatic and disseminated. The former, the less severe of the two, is characterized by mild influenza and/or pneumonia symptoms of short duration. The latter may mature into coccidioid meningitis, pneumonia, osteomyelitis and, occasionally, result in death.

EXPOSED POPULATIONS (4.1.3)

- (1) Visitors to and residents of endemic areas
- (2) Individuals exposed to contaminated products originating in an endemic area
- (3) Laboratory workers exposed to the pathogen.

COMPARATIVE SUSCEPTIBILITY OF EXPOSED POPULATIONS (4.1.4)

- o The simpler form, known as symptomatic coccidioidomycosis, affects men and women equally. Approximately 40 percent of all infected individuals exhibit clinical manifestations. Five percent of those progress to the disseminated stage. This more serious form is found more often in men than in women, the exception being that pregnant women appear to be more susceptible.
- o Racial and sexual predisposing factors appear to exist. The likelihood that the mild form will progress to the disseminated stage in a black adult male is 10-20 times greater than it is for a white male. A Filipino adult male is 175 times more likely than his white counterpart to experience the disseminated stage.
- o An estimated 1/500 nonpregnant white females will progress to the disseminated stage, as opposed to a 1/100 probability for adult white males.
- o Black adults show a higher probability of experiencing the disseminated stage than do white adults.
- o Pregnant white females are more likely to exhibit signs of infection than are their nonpregnant counterparts. This is especially true if a primary infection occurs during the third trimester.
- o Conditions which reduce the effectiveness of the immunological system may activate a latent primary condition and push it into the disseminated stage.
- o Other factors implicated as making certain individuals more susceptible to infection are: (1) certain blood groups and/or transplantation antigen allergic type and (2) underlying disease or therapeutic states such as malignant neoplasms, collagen vascular diseases, diabetes mellitus, and renal failure.

- o Long-term residents of an endemic area exhibit a relatively low incidence of serious coccidioidal disease due to the development of natural immunities following an initial infection.
- o Based on the coccidioidin skin test, it is estimated that from 60-90 percent of exposed individuals do, in fact, experience a form of the disease and develop antibodies which inhibit reinfection. Note should be made that a more sensitive skin test, utilizing sphereulin, is capable of identifying one-third more cases.

ENVIRONMENTAL COMPONENTS OF DISEASE ETIOLOGY (4.1.5)

- o Moisture in soil provides an excellent medium for spore proliferation and the subsequent drying of soil leaves the spores susceptible to transport.
- o Evidence exists that C. immitis, and the incidence of coccidioidomycosis, will increase following the disturbances of soils which had not been disturbed for significant periods of time. The exception is associated with those soils having a high organic content which serves to encourage competition between C. immitis and other microorganisms.

DIAGNOSIS (4.1.6)

Achieved through one of the following analyses:

- (1) recovery of cocci fungus from the patient's sputum or other body fluid,
- (2) blood tests, and
- (3) skin tests.

Note that not all tests will prove positive at all stages of the infection. Therefore, all suspected cases should be tested.

TREATMENT (4.1.7)

Approximately 60 percent of the infected population does not develop the symptoms of a primary infection. Milder symptoms, such as a sore throat, are of a short duration and persist only until natural immunity is developed. Individuals suffering the primary or symptomatic form of the disease will probably require treatment to relieve the discomfort. Those with the disseminated form will need to be treated with a specialized drug and are usually hospitalized. Occasionally surgery will be performed to remove diseased tissue.

SUMMARY (4.1.8)

Coccidioidomycosis is a disease frequently encountered by individuals living and working in endemic areas of Coccidioides immitis. The airborne fungal spores enter the body through inhalation. Initially a disease of the lungs, it can advance to the disseminated stage and be fatal. Most exposure to the agent results in a mild infection and the development of natural immunological properties which inhibit reinfection. Approximately 40 percent of the infected individuals would exhibit the

symptoms of the primary infection. Other cases, particularly among pregnant women, blacks, Filipinos and individuals with a reduced capacity to produce antibodies, have a higher likelihood of progressing to the disseminated stage. This advanced stage of the disease can have debilitating effects on the individual and eventually, cause death. Soil disturbance and soil moisture in endemic areas effectuate an increased exposure and subsequent rate of incidence. Suspected infection should be tested and treated accordingly.

4.2 M-X CONSTRUCTION AND COCCIDIOIDOMYCOSIS

Potential M-X construction activities will occur in endemic areas wherein Coccidioides immitis spores exist in the upper layers of the soil. Soil disturbance related to these activities will increase the quantity and concentration of airborne pathogens. Workers would be exposed to the agent and subsequent infections can be expected. Additionally, the windborne agent would be transported to other areas of human concentration, both M-X-related and non-M-X-related, with a similar increase in exposure levels and incidence rates.

The use of water for dust suppression would also cause an increase in the spore concentration in soils. It has been shown that moist soil provides an excellent growth medium and that, subsequently, turbulent air would suspend and transport greater quantities of the pathogen. This becomes particularly true when the soil dries and the components are less cohesive and therefore more vulnerable to transport.

Factors to be considered in evaluating the potential impact of this health problem include the sexual and racial composition of the exposed population and other predisposing conditions which individuals might exhibit. Should a high incidence of the infection occur, M-X management might experience a significant amount of lost work days. Health care services should be prepared to respond to a relatively high incidence of the disease. Local residents will also be exposed to spores generated by M-X-related activities. The extent of their exposure will be dependent upon meteorological conditions and individual behavior patterns. The extent of infections which would result is dependent upon similar factors as those outlined above.

4.3 MANAGEMENT

Effective management of coccidioidomycosis depends primarily on the implementation of an effective health education program. The program's goal would be to advise persons either working, living, or traveling in the area of the presence of C. immitis and of the need to be tested for the infection should symptoms appear. All elements of the supporting health care delivery system should be alerted that an increase in the incidence of valley fever is anticipated.

All health care facilities should be prepared to, or have access to resources which can:

- o administer skin tests (the administering of skin tests to all employees before starting employment and upon termination should be considered)
- o perform any required body fluid analysis to determine the nature and extent of the illness

- o administer appropriate treatment
- o identify predisposed individuals and groups which merit close attention through the development of individual health profiles.

Exposure to infection causing spores can be reduced by:

- o revegetation of exposed soils immediately after construction,
- o use of nondust-producing road surfaces,
- o avoiding excessive use of water on exposed soils, and
- o incorporating organic matter into disturbed soil as soon as possible.

5.0 MITIGATIVE TECHNIQUES

Measures that can be used to reduce the risk associated with the health concerns identified here are described below.

5.1 AMBIENT RADIOACTIVITY

To control or eliminate potentially harmful exposure to resuspended radioactive particles associated with soil disturbance and dust generation, the Air Force has agreed to an energetic dust suppression and control program as part of its overall air quality mitigative activities (ETR-38). The following are of particular import: (1) system design objectives which minimize soil disturbance; (2) dust suppression procedures during construction; (3) revegetation of disturbed areas; and (4) the use of respirators by personnel in the immediate vicinity of dust generating activities, as required by OSHA and NRC standards.

Other desirable potential mitigative measures include:

- (1) the development of relationships with the U.S. Environmental Protection Agency and the U.S. Public Health Service which are responsible for managing the off-site Radiological Safety Program. The Air Force should secure cooperation in the effective monitoring of ambient radiation in the area of M-X deployment activities.
- (2) the Air Force should develop a response system capable of directing and implementing precautionary measures in the event of excessive levels of ambient radiation.
- (3) implementation of a "spot check" system for monitoring the concentration of radon in open excavation pits during periods of activity therein.

5.2 FIBROUS ZEOLITES

Air Force dust suppression measures described in ETR-38 will mitigate against the inhalation of fibrous zeolites. In view of the uncertainty associated with the issue, the Air Force Surgeon General will evaluate the relationships between zeolites and human health in order to determine if mitigation measures more extensive than those for dust suppression are warranted. Prior to the commencement of construction, the Air Force Surgeon General will make specific recommendations to the Army Corps of Engineers concerning appropriate mitigative measures. If there were to be serious health effects from the materials, these effects would be manifested only after many years; therefore, individual health records, reflecting cumulative exposure levels, should be developed and retained.

5.3 COCCIDIOIDOMYCOSIS (VALLEY FEVER)

Mitigative measures developed by the Air Force affecting air quality (ETR-38) are generally effective in limiting the impact of valley fever on public health. But dust control techniques involving the use of water have a countervailing effect in the case of Coccidioides immitis. While water is effective in its dust suppressive role, it also provides an excellent breeding medium for the proliferation of fungal spores. Thus, there is a trade-off, which, while clearly favoring the use of water, adds a complicating dimension to the problem.

Other mitigative measures that might be implemented are: (1) the development and implementation of an effective health education program targeted at all individuals likely to be exposed to C. immitis; (2) alert all elements of the health care delivery system that an increase in the reported incidence of valley fever is anticipated, and ensure that all medical facilities are prepared to administer skin tests, perform any required laboratory analysis, and administer appropriate treatment; (3) perform skin tests on all employees at the beginning of employment, and upon termination; (4) perform an analysis of the work force on an on-going basis, to identify predisposed individuals and groups of individuals which merit close attention. The development of individual health profiles should be accomplished by health care personnel; (5) use of techniques for dust suppression which are not dependent on moisture for long-term effectiveness; (6) avoidance of the excessive use of water on exposed soils; and (7) the incorporation of organic matter into soils as soon as possible.

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6.1 RADIOACTIVITY

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