Environmental Radiological Surveillance Report on Oregon's Terrestrial Environment

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Ray D. Paris, Manager
Oregon Health Division
Radiation Protection Services, Ste 260
800 NE Oregon Street
Portland, OR 97232

(503) 731-4014
Fax (503) 731-4081

Prepared by

the

Oregon Health Division
RADIATION PROTECTION SERVICES

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This report assesses the levels of radioactivity in the terrestrial environment of Oregon during the years 1961 through 1993. It documents naturally occurring activity from cosmic interactions and from the minerals in the rocks and soils. It also documents the terrestrial impact from man-made activities worldwide, including atmospheric nuclear weapons testing and radioactivity from the Hanford and Trojan nuclear operations.

Naturally occurring radioactivity varied according to the type of media sampled and the location.

Man-made radioactivity also varied by media and location. The primary sources were fallout, specifically from nuclear weapons testing and the Chernobyl accident in the Soviet Union. The Hanford installation in southeastern Washington and the Trojan Nuclear Plant near Rainier, Oregon, contributed no detectable radioactivity to their terrestrial environments.

Even though elevated levels of radioactivity were detected from both natural and man-made sources (primarily in milk and groundwater), they were below the maximum permissible concentrations stated by the International Commission on Radiological Protection and Measurements (ICRP).

Over the 33 years covered by this report, the Oregon Health Division never found it necessary to limit public consumption of water, milk, or other food products derived from the terrestrial environment due to the presence of natural or man-made radioactivity. In 1986, however, intrusions of radioactivity from the Chernobyl accident led the division to issue a precautionary advisory stating, "An alternate drinking water source should be used by Oregon residents who rely solely upon rainwater for drinking."

This report presents data on the levels of radioactivity and radionuclides observed and followed in air, milk, groundwater, precipitation, terrestrial vegetation, and soil, as well as ambient radiation levels measured throughout Oregon, from 1961 through 1993. (Information on radioactivity in Oregon's aquatic environment is available from the Oregon Health Division in the

, dated
December 1994. (Contact Radiation Protection Services, Suite 260, 800 NE Oregon Street, Portland, Oregon 97232.)

During the surveillance period, radioactivity in Oregon's terrestrial environment originated from:

1. Natural sources, specifically the radionuclides in the uranium and thorium decay series and naturally occurring potassium;
2. Fallout from atmospheric weapons testing conducted by the Union of Soviet Socialist Republics (USSR), the United States, and China;
3. The Chernobyl nuclear accident in Russia;
4. The Trojan Nuclear Plant, and
5. Atmospheric and underground weapons testing programs conducted at the Nevada Test Site.

The most significant intrusions of radioactivity occurred primarily during the period 1961 through 1963, and were products of atmospheric testing by Russia and the United States. The two countries signed the Atmospheric Nuclear Test Ban Treaty in 1963, but testing by the Chinese continued to affect the environment into the 1980s. The most recent source of fallout radioactivity in Oregon was the 1986 nuclear reactor accident at Chernobyl in the Soviet Union.

In 1956, the U.S. Public Health Service established the Radiation Surveillance Network in cooperation with the U.S. Atomic Energy Commission. Its purpose was to provide a means of evaluating increases in levels of radioactivity in air and precipitation caused by atmospheric fallout from nuclear weapons tests. The network initially

consisted of 45 stations at urban locations operated by state and local health departments, and Public Health Service personnel. The station in Portland, Oregon, has been operated continually since 1956 by the Oregon Health Division (formerly called the Oregon Board of Health).
In time, other networks were established nationwide and worldwide to evaluate terrestrial and aquatic environments for radioactivity in surface waters, drinking waters, milk, and other foods. In 1972, thermoluminescent dosimetry (TLD) was added at Radiation Surveillance Network sites to detect background radiation levels and document any significant variations above background.

Data compiled by the networks were originally published by the U.S. Public Health Service in
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Subsequently, they have been published by the Environmental Protection Agency in
and, most recently, in the
limited report .

In 1961, the Oregon Health Division established the Environmental Radiation Surveillance Program, a statewide network to define, follow, and evaluate natural and man-made radionuclides in the Oregon environment. The objective was to assess the public health significance to Oregonians in the event of intrusions of fallout activity from nuclear weapons testing or radioactivity from other sources.

All environmental media contain radioactivity from natural sources, including cosmic interactions, the uranium and thorium decay series, and elements such as potassium. Stable potassium contains about 0.0118 % of radioactive potassium-40. Other radionuclides commonly found in detectable concentrations are beryllium-7 and carbon-14 from cosmic interactions; uranium-238, radium-226 and radium-228 from the uranium decay series, and thorium-230 and thorium-232 from the thorium decay series.

Environmental media also contain man-made radioactivity originating from weapons testing programs and nuclear reactors. Some 200 different radionuclides are formed at the instant of a nuclear detonation; most have short half-lives and decay quickly, or are highly insoluble or have other characteristics that lessen their impact on the environment.

The detected radionuclides were iodine-131, cesium-134, cesium-137, barium-lanthanum-140, zirconium-niobium-95, cerium-141, cerium-144, ruthenium-103, ruthenium-106, strontium-89 and strontium-90. The levels observed are dependent on the concentrations in the ambient environment and the ability of the media to concentrate this radioactivity. Half-lives range from a few days to many years, and can either disappear rather quickly or remain in certain media for many years.

The appendices of this report summarize data for each type of environmental media sampled into five-year increments starting in 1962, or when data was first available, and ending in 1993.

Radon and thoron, naturally occurring radioactive gases that originate from the soils, are always present in the natural radiation environment in very low concentrations and vary according to geological conditions and weather.

Air is an important exposure pathway, as intrusions of man-made radioactivity into the terrestrial environment are first detectable in the air as particulate and/or gaseous activity. These make up a mixture of short- and long-lived fission products that are both beta and gamma emitters. Therefore, monitoring the gross beta activity of air particulate provides one of the earliest and most sensitive indications of increased radioactivity in the environment.

Air particulate in Oregon air generally remains below 0.1 pCi/cubic meter. (An "alert level" commonly used in the past by the Pub-

lic Health Service Air Surveillance Network was 10 pCi/cubic meter.) The highest level recorded in Oregon was 640 pCi/cubic meter in Klamath Falls in the mid 1950s, a result of airborne activity moving north from atmospheric weapons testing at the Nevada Test Site.

Many instances of elevated levels were detected in the 1960s as radioactive clouds passed over Oregon. These clouds originated from atmospheric weapons testing in the Pacific by the Soviet Union and the United States. Although the two countries had signed the Atmospheric Test Ban Treaty in 1963, short-term intrusions of airborne activity (summarized below) continued into the 1980s following tests by the Chinese. The last significant levels of fallout activity in Oregon were detected in 1986 following the Chernobyl nuclear reactor accident in the Soviet Union.

		APPROXIMATE YIELD (Kilotons)	
YEAR	DATE	TOTAL	FISSION
1964	Oct 16	20	20
1965	May 14	40	40
1966	May 9	300	300
	Oct 28	20	20
	Dec 28	300	300
1967	Jun 17	3000	1600
	Dec 24	20	20
1968	Dec 28	3000	1900
1969	Sep 29	3000	1800
1970	Oct 14	3000	3000
1971	Nov 18	20	20
1972	Jan 7	<20	<20
	Mar 18	20-200	20-200
1973	Jun 27	2000-3000	1400
1974	Jun 17	200-1000	200-1000
1976	Jan 23	<20	<20
	Sep 26	20-200	20-200
	Nov 17	4000	2000
1977	Sep 17	<20	<20

The above summary, compiled from Energy Research and Development Administration (ERDA) reports, details the major Chinese atmospheric tests.

Radioactivity from the Chinese tests was observed in aquatic vegetation throughout Oregon and in Amchitka, Alaska. Data on the levels observed in Amchitka have been detailed in progress reports prepared by Drs. Allyn Seymour and Arthur F. Johnson of the University of Washington. Their investigation showed good agreement between concentrations of zirconium-95/niobium-95 found in Oregon freshwater aquatic vegetation and that of

Fontinalis algae from Amchitka.

Monitoring gross beta radioactivity in precipitation is another important means of evaluating intrusions of fallout activity, particularly since radioactive contaminants in rain soon find their way into the food chains. The trends here generally follow those found in particulate air samples. The highest level recorded in Oregon was 9,100 pCi/liter recorded in the late 1960s at Portland and originated from Chinese atmospheric weapons tests. More recently, a level of 150 pCi/liter was observed at Portland in 1986 following the Chernobyl accident in Russia. These elevated levels were largely from short-lived fission products such as iodine-131, strontium-89 and barium-lanthanum-140, and disappeared in a few months largely through radioactive decay. (It should be noted that a direct biological hazard cannot be evaluated using gross beta activity values alone.)

Terrestrial vegetation consists primarily of grass growing at statewide sampling sites where soil was collected and ambient radiation measurements were made. In certain areas of the Wallowa and Cascade mountains, lichens (which grow on trees) were also sampled. This vegetation contains naturally occurring potassium-40 and beryllium-7 in varying concentrations, depending on location and type of sample. Also present were the fallout radionuclides cesium-137 and strontium-90, and they too appear to be dependent on location and type of sample.

When the Chernobyl accident produced intrusions of fresh fission products in 1986, Oregon pasture grass was found to contain readily detectible concentrations of iodine-131. These concentrations decayed according to the radionuclide's 8.1 day half-life. Following a subsequent intrusion, an increase over the previous levels could be easily detected.

Soils throughout Oregon contained natural and man-made radioactivity in levels that varied according to location and characteristics of the sample. The finer clay-type soils contained the highest levels of both natural and fission product activity. The radionuclides observed and monitored were principally naturally-occurring potassium-40, radium-226, and thorium-232. They did not vary significantly from the average values measured at the sampling locations during the course of surveillance.

The longer-lived fission product radionuclides originating from atmospheric fallout, specifically, cesium-137 and strontium-90, were detectable in most soils at low concentrations. These radionuclides are tightly bound to the soil matrix and with half-lives of 30 and 28 years, respectively, will be detectable in the Oregon soils for many years to come.

Milk is but one of many dietary sources of radionuclides, but it is the food item most useful as an indicator of human intake of radionuclides from the environment. The important radionuclides that can be monitored in milk are iodine-131, strontium-89, strontium-90, cesium 137, and barium-lanthanum-140. Milk also contains naturally occurring potassium-40, the level being dependent on the amount of stable potassium, but averages about 1,500 pCi/liter.

When intrusions of fresh fission products have been observed in Oregon's atmosphere, they have been detected in milk supplies as soon as two days later.

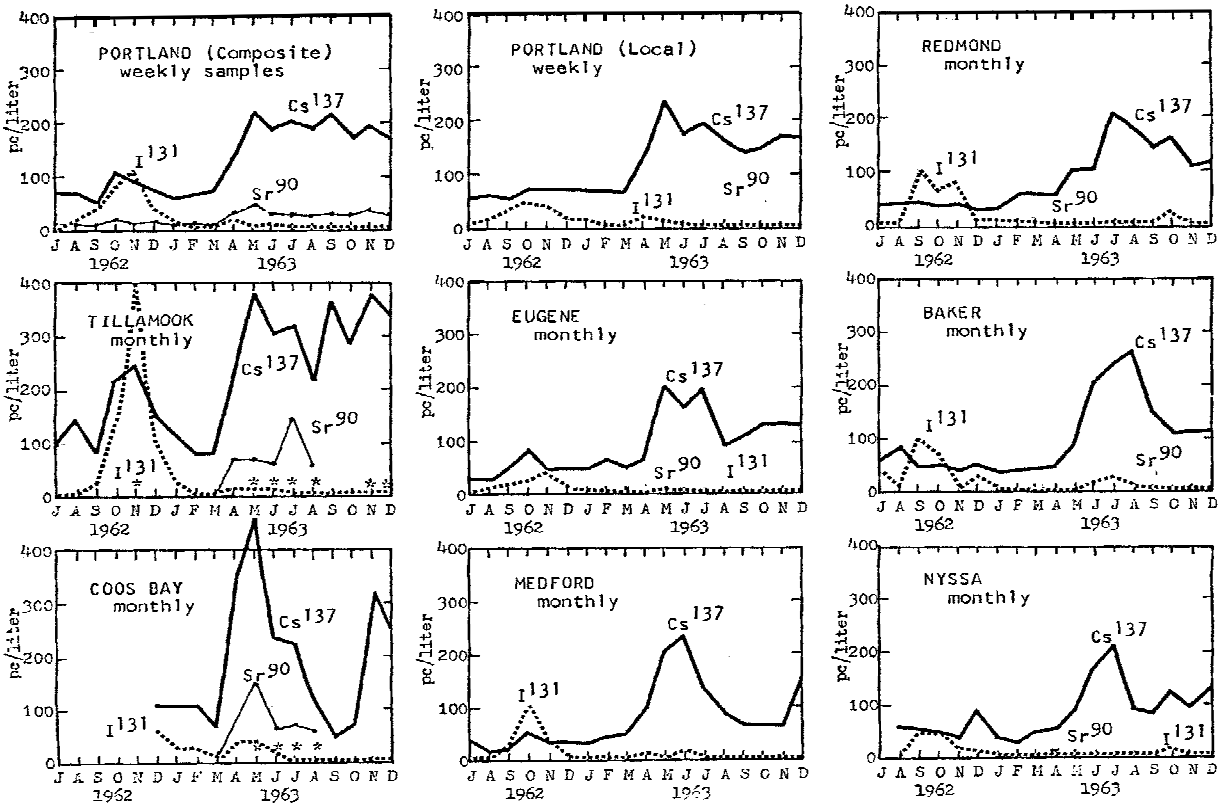
The highest levels in Oregon milks were observed at the sampling locations in the Oregon Coast milk districts (Tillamook and Coos Bay). In 1962, levels at these locations routinely measured in the range of 400 pCi/liter for iodine-131, 500 pCi/liter for cesium-137, and 150 pCi/liter for strontium-90. Levels observed in the Willamette Valley

dairies were

significantly lower, and those in the milk producing areas of Eastern Oregon were the lowest. (These comparisons can be seen by referring to the graphs below.) Noticeably elevated levels of radionuclides in milk have also been observed at different times in the 1970s, originating in China. The most recent instance of elevated levels in milk causing concern resulted from the Chernobyl accident in 1986.

Iodine-131 is the radionuclide of primary concern when ingested because it is con-cent rated in the thyroid gland, especially in the case of an infant's more susceptible thyroid. However, average concentrations of radionuclides, including iodine-131, have never reached a level in Oregon's milk supplies to warrant any public health action beyond increased sampling frequency at specific locations.

Radionuclide Concentrations in Oregon Milk Samples



Environmental gamma radiation levels were determined at fixed terrestrial sampling sites statewide. The exposure rates measured at these

locations were attributed to cosmic radiation, fallout, and the terrestrial radioactivity from potassium-40 and the natural decay series of uranium-238 and thorium-232. Average exposure rates statewide varied from 0.1 to 0.2 mR/day, as determined through the use of thermoluminescent dosimeters which were exchanged quarterly at most locations.

Measurements were taken with a Reuter- Stokes Pressurized Ionization Chamber from 1980 through 1987. They varied from an average of 0.141 mR/day at the Bull Run Headworks sampling location, to 0.240 mR/day at a high-altitude sampling location in the Wallowa Mountains of Eastern Oregon. The gamma spectra taken at these locations indicated that fallout from nuclear weapons tests made up the smallest component of the total gamma radiation field.

A significant part of the average exposure rate is made up of cosmic radiation. According to "Absolute Cosmic Ray Intensities (Latitude North 50 degrees) in the Lower Atmosphere" (Lowder and Beck, Journal of Geophysics Research, 72(19), p.4661, 1966), the cosmic component of the measured exposure rate in Oregon varies from 0.086 mR/day at the Tillamook Bay sea level location, to approximately 0.142 mR/day at the 5,500 foot elevation in the Wallowa Mountains. The remaining component of the exposure rates measured consisted of the natural radioactivity in the surrounding terrestrial environment.

The groundwater surveillance network consisting of 30 wells, was established to monitor natural radioactivity in the large underground aquifers throughout Oregon. The levels in the individual wells did not vary significantly over the 32-year period covered by this study; however, there were marked variations by location. The deep wells of Eastern Oregon and those along the Columbia River showed the highest levels of gross alpha and gross beta activity, a product of the radioactive minerals naturally present in those aquifers.

We have always lived in a terrestrial environment filled with many sources of radiation, including radioactive materials that accumulate through natural processes in our bodies. In addition, we are constantly being bombarded by cosmic rays from outer space and affected by their interactions.

Radiation has not been shown to have a beneficial effect on the existence of life; therefore, health physics practices have applied the concept of limiting our exposure to "as low as reasonably achievable" (ALARA). With that in mind, it is important to define and document exposure to naturally occurring radioactivity throughout Oregon's terrestrial environments. This provides the baseline for evaluating total exposure once the contributions from man-made sources have been added.

The nuclides that contribute to the natural exposure have been extensively reviewed by Lowder and Solon, 1956, "UNSCEAR 1962." It was concluded that potassium-40 and the radioactive decay chains of uranium-238 and thorium-232 can be assumed to account for practically all of our terrestrial exposure. Radon alone accounts for 55% of the radiation exposure for the average U.S. citizen.

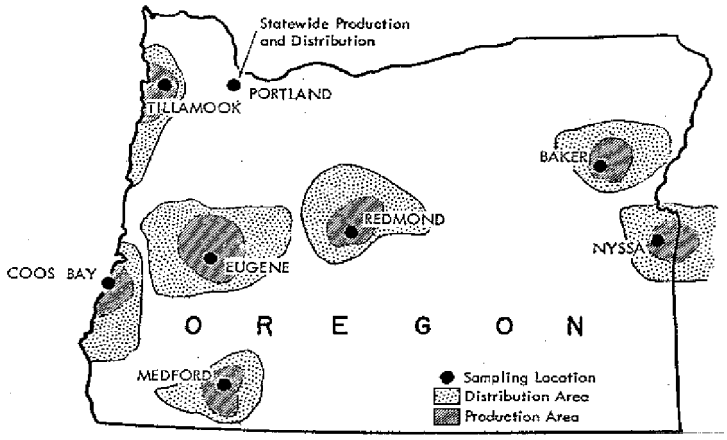
Agencies such as the International Commission on Radiological Protection and Measurements defined "maximum permissible concentrations," which can be applied to evaluating exposure to man-made sources of radioactivity. The levels observed in the environmental media sampled during this study were all well below these established levels.

Oregon comprises many varied ecological environments of distinct characteristics containing different levels of natural and man-made radioactivity from various sources. This diversity required that a number of statewide sampling networks be established:

(1) The Milk Surveillance Network, sampling the major milk districts supplying most of the milk produced and distributed in Oregon;
(2) the Groundwater Surveillance Network, sampling the large underground aquifers throughout Oregon; and
(3) the Ambient Sampling Network, sampling collections of air, particulates, vegetation, precipitation, soil, and ambient dose rates in regions throughout the state with different ecological and climatic conditions.

The following tables and maps show the locations of these networks' sampling points.

(showing production and distribution areas)



Milk District	Location of Sampling	County
Tillamook	North Coastal Areas	Tillamook
Coos Bay	South Coastal Areas	Coos
Portland	Statewide	Tillamook, Multnomah, Columbia
Eugene/Corvallis	Southern Willamette Valley	Linn & Lane
Medford	Southern Oregon	Jackson
Redmond	Central Oregon	Deschutes
Baker	Northeast Oregon	Union
Nyssa	Eastern Oregon & Southern Idaho	Malheur