FirstEnergy

Davis-Besse Nuclear Power Station
5501 North State Route 2
Oak Harbor, Ohio 43449-9760

May 13, 2002

50-346

DSC-02-00046

Director, Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
NMSS/OD Mail Stop T-8A23
Washington, D.C. 20555-0001

Ladies and Gentlemen:

Enclosed is a copy of the Davis-Besse Nuclear Power Station 2001 Annual Radiological Environmental Operating Report (AREOR). The 2001 AREOR is similar in format and content to those of previous years, and furthers our effort in educating the public about the compatibility of nuclear power and the environment.

As in previous years' reports, the 2001 AREOR contains information on the Radiological Environmental Monitoring Program, as well as information on meteorological monitoring, hazardous chemical management, water and wastewater treatment, and the management of the 730-acre wetland located on the site. In addition, the Radioactive Effluent Release Report for 2001 and background information on basic health physics, nuclear power generation, and a discussion of the health risks of dose are also included in the report.

If you have any questions or comments, or would like further information, please contact Mr. Bruce Geddes at (419) 321-7388.

Very truly yours,

Patrick J. McCloskey
Manager – Environmental and Chemistry

AMP/ses

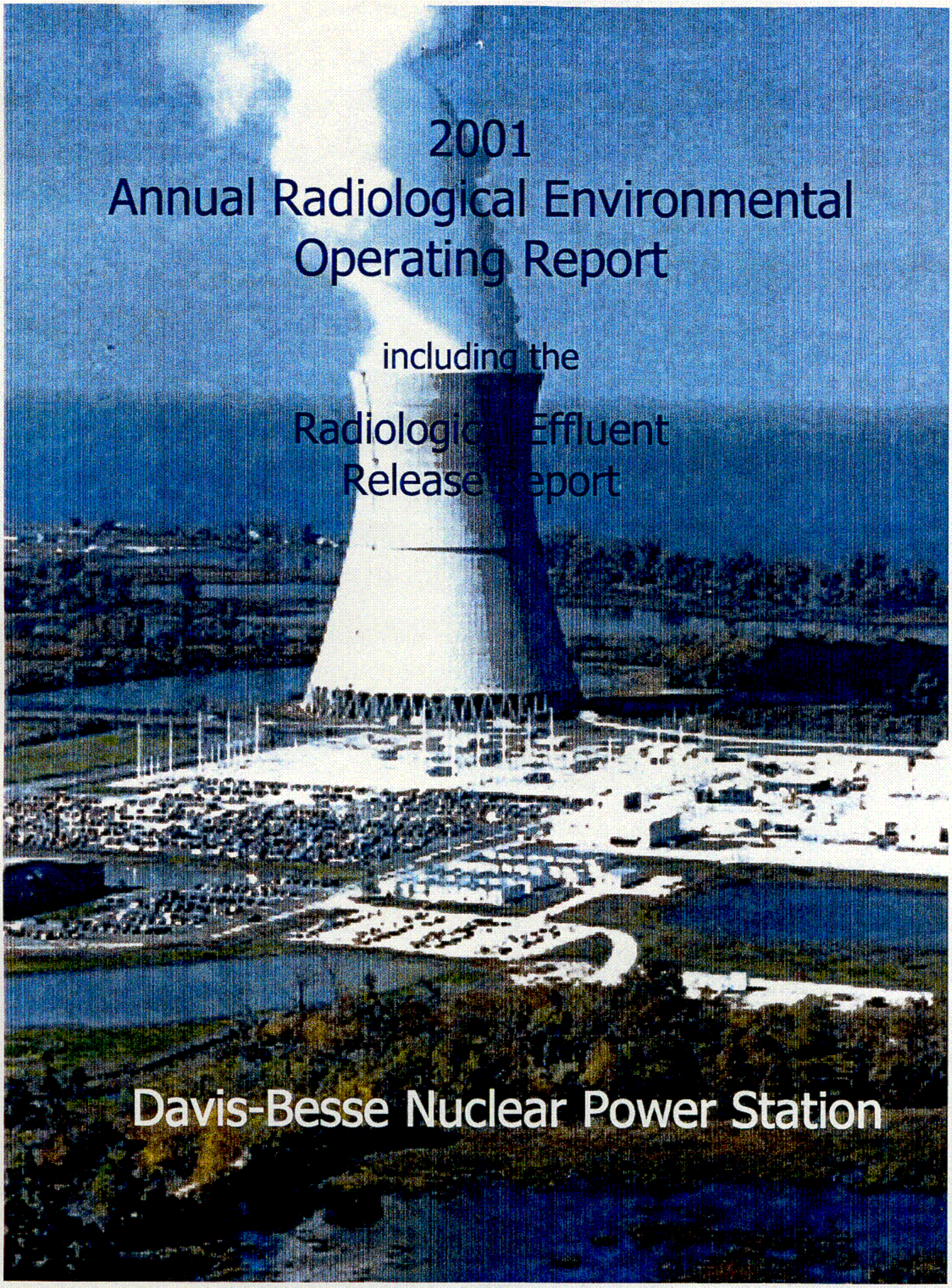
Enclosure

IE25
IE48

2001 Annual Radiological Environmental Operating Report

including the

Radiological Effluent Release Report



Davis-Besse Nuclear Power Station

C01

ANNUAL RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

Davis-Besse Nuclear Power Station
January 1, 2001 through December 31, 2001

Prepared by: Date: 4/29/02
Bruce L. Geddes
Supervisor – Nuclear Chemistry Services

Date: 4/29/02
Alfred M. Percival Jr.
Nuclear Chemistry Technologist – Nuclear Chemistry Services

Approved by: Date: 04/29/02
Patrick J. McCloskey
Manager – Environmental and Chemistry

Davis-Besse Nuclear Power Station

April 2002

TABLE OF CONTENTS

List of Tables

List of Figures

Executive Summary

The Annual Radiological Environmental Operating Report (AREOR) is a detailed report on the Environmental Monitoring Programs conducted at the Davis-Besse Nuclear Power Station from January 1 through December 31, 2001. This report meets all of the requirements in Regulatory Guide 4.8, Davis-Besse Technical Specifications 6.9.1.10, and Davis-Besse Offsite Dose Calculation Manual (ODCM) Section 7.1. Reports included are the Radiological Environmental Monitoring Program, Land Use Census, and the Non-Radiological Environmental Programs, which consist of Meteorological Monitoring, Land and Wetland Management, Water Treatment, Chemical Waste Management, and Waste Minimization and Recycling. This report also includes the Radiological Effluent Release Report for the reporting period of January 1 through December 31, 2001.

Radiological Environmental Monitoring Program

The Radiological Environmental Monitoring Program (REMP) is established to monitor the radiological condition of the environment around Davis-Besse. The REMP is conducted in accordance with Regulatory Guide 4.8, Davis-Besse Technical Specification 6.8.4.d and the Davis-Besse ODCM Section 6.0. This program includes the sampling and analysis of environmental samples and evaluating the effects of releases of radioactivity on the environment.

Radiation levels and radioactivity have been monitored within a 25-mile radius around Davis-Besse since 1972. The REMP was established at Davis-Besse about five years before the Station became operational. This pre-operational sampling and analysis program provided data on radiation and radioactivity normally present in the area as natural background. Davis-Besse has continued to monitor the environment by sampling air, groundwater, milk, edible meat, fruit and vegetables, animal feed, soil, drinking water, surface water, fish, shoreline sediment, and by direct measurement of radiation.

Samples are collected from indicator and control locations. Indicator locations are within approximately 5 miles of the site and are expected to show naturally occurring radioactivity plus any increases of radioactivity that might occur due to the operation of Davis-Besse. Control locations are farther away from the Station and are expected to indicate the presence of only naturally occurring radioactivity. The results obtained from the samples collected from indicator locations are compared with the results from those collected from control locations and with the concentrations present in the environment before Davis-Besse became operational. This allows for the assessment of any impact the operation of Davis-Besse might have had on the surrounding environment.

Over 2000 radiological environmental samples were collected and analyzed in 2001. An explanation for the sample anomalies for this reporting period is provided on page 36.

The results of the REMP indicate that Davis-Besse continues to be operated safely in accordance with applicable federal regulations. No significant increase above background radiation or radioactivity is attributed to the operation of Davis-Besse.

The sampling results are divided into four sections: atmospheric monitoring, terrestrial monitoring, aquatic monitoring and direct radiation monitoring:

- Air is continuously being filtered at 10 locations, onsite and up to 25 miles away, and the filters are collected to monitor the atmosphere. The 2001 results are similar to those observed in preoperational and previous operational programs. Only background and fallout radioactivity normally present in the environment was detected and only at concentrations normal to the area.

- Terrestrial monitoring includes analysis of milk, ground water, meat, fruits, vegetables, animal feed and soil samples. Samples are collected onsite and up to 25 miles away depending on the type of sample. Results of terrestrial sample analyses indicate concentrations of radioactivity similar to previous years and indicate no build-up of radioactivity due to the operation of Davis-Besse.

- Aquatic monitoring includes the collection and analysis of drinking water, untreated surface water, fish and shoreline sediments from onsite and the vicinity of Lake Erie. The 2001 results of analysis for fish, untreated surface water, drinking water and shoreline sediment indicate normal background concentration of radionuclides and show no increase or build-up of radioactivity due to the operation of Davis-Besse.

- Direct radiation averaged 14.4 mrem/91days at indicator locations and 14.8 mrem/91 days at control locations. This is similar to results of previous years.

The operation of Davis-Besse in 2001 caused no significant increase in the concentrations of radionuclides in the environment and no adverse effect on the quality of the environment. Radioactivity released in the Station's effluents was well below the applicable federal regulatory limits. The estimated radiation dose to the general public due to the operation of Davis-Besse in 2001 was well below all applicable regulatory limits.

In order to estimate radiation dose to the public, the pathways through which public exposure can occur must be known. To identify these exposure pathways, an Annual Land Use Census is performed as part of the REMP. During the census, Station personnel travel every public road within a radius of five miles of Davis-Besse to locate radiological exposure pathways (e.g., residences, vegetable gardens, milk cows/goats, etc.). The one pathway of particular interest is the pathway that, for a specific radionuclide, provides the greatest dose to a sector of the population. This is called the critical pathway. The critical pathway for 2001 was a garden in the West sector 1610 meters from Davis-Besse.

Radiological Effluent Release Report

The Radiological Effluent Release Report (RERR) is a detailed listing of radioactivity released from the Davis-Besse Nuclear Power Station during the period January 1, 2001 through December 31, 2001. The doses due to radioactivity released during this period were estimated to be:

Liquid Effluents:

Maximum Individual Whole Body Dose	7.75E-02 mrem (0.0775 mrem)
Maximum Individual Significant Organ Dose	8.03E-02 mrem (0.0803 mrem)
Total Integrated Population Dose	7.31E-01 person-rem (0.731 person-rem)
Average Dose to the Individual	3.35E-04 mrem (0.000335 mrem)

Gaseous Effluents:

Maximum Individual Whole Body Dose due to I-131, H-3 and Particulates with half-lives greater than 8 days	1.99E-03 mrem (0.00199 mrem)
Maximum Significant Organ Dose due to I-131, H-3 and Particulates with half-lives greater than 8 days	2.54E-03 mrem (0.00254 mrem)
Total Integrated Population Dose due to I-131, H-3 and Particulates with half-lives greater than 8 days	7.02E-03 person-rem (0.00702 person-rem)
Average Dose to an individual in the population due to I-131, H-3 and Particulates with half-lives greater than 8 days	3.21E-06 mrem (0.00000321 mrem)
Maximum Individual Skin Dose due to noble gases	9.27E-04 mrad (0.000927 mrad)
Maximum Individual Whole Body Dose due to noble gases	2.71E-04 mrad (0.000271 mrad)
Total Integrated Population Dose due to noble gases	5.03E-04 person-rem (0.000503 person-rem)
Average Dose to individual in population due to noble gases	2.30E-07 mrem (0.000000230 mrem)

The Total Body doses to an individual and population in an unrestricted area due to direct radiation from Davis-Besse is not distinguishable from background. These doses represent an extremely small fraction of the limits set by the NRC or the limits set in the ODCM.

The abnormal gaseous releases during this reporting period are listed on page 89.

There were no changes to the Process Control Program (PCP) and two alterations to the ODCM, Revision 14.0 and Revision 15.0, during this reporting period.

Non-Radiological Environmental Programs

Meteorological Monitoring

The Meteorological Monitoring Program at Davis-Besse is part of a program for evaluating the radiological effects of the routine operation of Davis-Besse on the surrounding environment. Meteorological monitoring began in October, 1968.

Meteorological data recorded at Davis-Besse include wind speed, wind direction, sigma theta (standard deviation of wind direction), ambient temperature, differential temperature, dew point and precipitation. Two instrument-equipped meteorological towers are used to collect data. Data recovery for the five instruments that are operationally required by Davis-Besse Technical Requirement Manual was 99.27 %.

Marsh Management

The FirstEnergy Company owns the Navarre Marsh. It is leased to the U.S. Fish and Wildlife Service, who manage it as part of the Ottawa National Wildlife Refuge.

Special projects conducted in 2001 with the cooperation of Ohio Department of Natural Resources included Canada goose banding and a Volunteer Eagle Watcher Workshop. Davis-Besse hosted the seventh annual Federal Junior Duck Stamp Art Contest for the State of Ohio in cooperation with the Ottawa National Wildlife Refuge.

Davis-Besse's resident pair of American Bald Eagles built a new nest and fledged three eaglets.

Water and Wastewater Treatment

Davis-Besse withdraws water from Lake Erie and processes it through its Water Treatment Plant to produce high-purity water for use in the Station's cooling systems.

Since December 1, 1998, domestic water at the site has been provided by the Carroll Township Water Treatment Plant.

Sewage is treated at the Davis-Besse Wastewater Treatment Plant (WWTP) and pumped to a large basin where, following a holdup period, the water is discharged with other station wastewater back to Lake Erie.

Chemical Waste Management

The Chemical Waste Management Program at Davis-Besse was developed to ensure that the offsite disposal of non-radioactive hazardous and nonhazardous chemical wastes is performed in accordance with all applicable state and federal regulations. Chemical waste disposal vendors contracted by Davis-Besse use advanced technology for offsite disposal, including recycling of chemical wastes, in order to protect human health and the environment.

In 2001, the Davis-Besse Nuclear Power Station qualified as a small quantity generator status, generating 5,770 pounds of hazardous waste. Other non-hazardous wastes generated include 2,250 gallons of used oil, 385 gallons of oil filters and solid oily debris, and 505 gallons of microfilm process chemicals and water treatment resins.

As required by Superfund Amendment and Reauthorization Act (SARA), Davis-Besse reported hazardous products and chemicals to local fire departments and local and state planning commissions. As part of the program to remove PCB fluid from Davis-Besse, all electrical transformers have been retrofilled and reclassified as non-PCB transformers.

Waste Minimization and Recycling

The Waste Minimization and Recycling Program at Davis-Besse began in 1991 with the collection and recycling of paper. This program was expanded and reinforced during 1993 to include the recycling of paper, aluminum cans, cardboard, and metal. Paper and cardboard recycling typically exceeds 50 tons annually. The scrap metal collected onsite is sold to scrap companies.

Appendices

Appendix A contains results from the Interlaboratory Comparison Program required by Davis-Besse Technical Specifications. Samples with known concentrations of radioisotopes are prepared by the Environmental Protection Agency (EPA), and then sent (with information on sample type and date of collection only) to the laboratory contracted by the Davis-Besse Nuclear Power Station to analyze its REMP samples. Results are checked against known standards by the EPA. The results from both the contracted laboratory and the EPA are provided in Appendix A.

Appendix B contains data reporting conversions used in the REMP at Davis-Besse. The appendix provides an explanation of the format and computational methods used in reporting REMP data. Information on counting uncertainties and the calculations of averages and standard deviations are also provided.

Appendix C lists the effluent concentration limits for alpha and beta-emitting radioisotopes and for certain other radioisotopes in air and water samples. These concentrations are taken directly from the Code of Federal Regulations, and provide comparison values for actual REMP sampling results for 2001.

Appendix D provides a REMP sampling summary from 2001. The appendix provides a listing of the following for each sample type:

- the number and types of analyses performed,
- the lower limit of detection for each analysis,
- the mean and range of results for control and indicator locations,
- the mean, range, and description of location with highest annual mean
- the number of non-routine results

For detailed studies, Appendix D provides more specific information than that listed in Chapter 2 of this report. The information presented in Appendices A through D was provided by Environmental, Inc. Midwest Laboratory in their Final Progress Report to Toledo Edison (February, 2002).

Introduction

Introduction

Coal, oil, natural gas and hydropower are used to run this nation's electric generating stations; however, each method has its drawbacks. Coal-fired power can affect the environment through mining, acid rain and air pollution. Oil and natural gas are in limited supply and are, therefore, costly. Hydropower is limited due to the environmental impact of damming our waterways and the scarcity of suitable sites.

Nuclear power provides a readily available source of energy. The operation of nuclear power stations has a very small impact on the environment. In fact, the Davis-Besse Nuclear Power Station is surrounded by hundreds of acres of marshland, which make up part of the Ottawa National Wildlife Refuge. In order to provide better understanding of this unique source of energy, background information on basic radiation characteristics, risk assessment, reactor operation and effluent control is provided in this section.

Fundamentals

The Atom

All matter consists of **atoms**. Simply described, atoms are made up of positively and negatively charged particles, and particles which are neutral. These particles are called **protons, electrons,** and **neutrons,** respectively (Figure 1). The relatively large protons and neutrons are packed tightly together in a cluster at the center of the atom called the **nucleus**. Orbiting around the nucleus are one or more smaller electrons. In an electrically neutral atom the negative charges of the electrons are balanced by the positive charges of the protons. Due to their dissimilar charges, the protons and electrons have a strong attraction for each other. This holds the atom together. Other attractive forces between the protons and neutrons keep the densely packed protons from repelling each other, and prevent the nucleus from breaking apart.

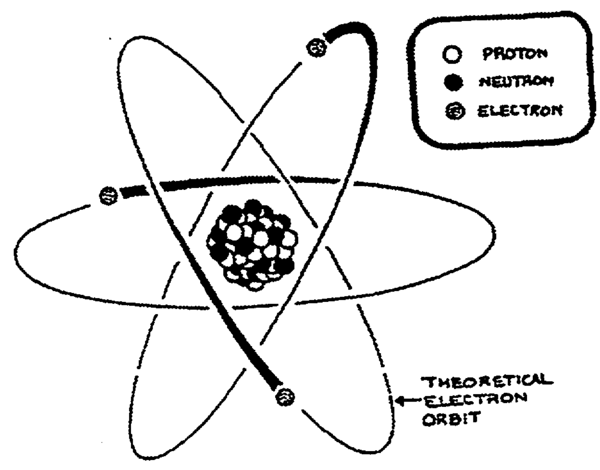


Figure 1: An atom consists of two parts: a nucleus containing positively charged protons and electrically neutral neutrons and one or more negatively charged electrons orbiting the nucleus. Protons and neutrons are nearly identical in size and weight, while each is about 2000 times heavier than an electron.

Radiation and Radioactivity

Isotopes and Radionuclides

A group of identical atoms containing the same number of protons make up an **element**. In fact, the number of protons an atom contains determines its chemical identity. For instance, all atoms with one proton are hydrogen atoms, and all atoms with eight protons are oxygen atoms. However, the number of neutrons in the nucleus of an element may vary. Atoms with the same number of protons but different numbers of neutrons are called **isotopes**. Different isotopes of the same element have the same chemical properties, and many are stable or nonradioactive. An unstable or radioactive isotope of an element is called a **radioisotope, a radioactive atom, or a radionuclide**. Radionuclides usually contain an excess amount of energy in the nucleus. The excess energy is usually due to a surplus or deficit in the number of neutrons in the nucleus. Radionuclides such as uranium-238, Berylium-7 and potassium-40 occur naturally. Others are man-made, such as iodine-131, cesium-137, and cobalt-60.

Radiation

Radiation is simply the conveyance of energy through space. For instance, heat emanating from a stove is a form of radiation, as are light rays, microwaves, and radio waves. **Ionizing radiation** is another type of radiation and has similar properties to those of the examples listed above. Ionizing radiation consists of both **electromagnetic radiation** and **particulate radiation**. Electromagnetic radiation is energy with no measurable mass that travels with a wave-like motion through space. Included in this category are **gamma rays** and **X-rays**. Particulate radiation consists of tiny, fast moving particles which, if unhindered, travel in a straight line through space. The three types of particulate radiation of concern to us are **alpha particles,** which are made up of 2 protons and 2 neutrons; **beta particles**, which are essentially free electrons; and **neutrons**. The properties of these types of radiation will be described more fully in the Range and Shielding section.

Radioactive Decay

Radioactive atoms, over time, will reach a stable, non-radioactive state through a process known as **radioactive decay**. Radioactive decay is the release of energy from an atom through the emission of ionizing radiation. Radioactive atoms may decay directly to a stable state or may go through a series of decay stages, called a **radioactive decay series**, and produce several **daughter products** that eventually result in a stable atom. The loss of energy and/or matter through radioactive decay may transform the atom into a chemically different element. For example, when uranium-238 decays, it emits an alpha particle and, as a result, the atom loses 2 protons and 2 neutrons. As discussed previously, the number of protons in the nucleus of an atom determines its chemical identity. Therefore, when the uranium-238 atom loses the 2 protons and 2 neutrons, it is transformed into an atom of thorium-234. Thorium-234 is one of the 14 successive daughter products of uranium-238. Radon is another daughter product, and the series ends with stable lead-206.

This example is part of a known radioactive decay series, called the uranium series, which begins with uranium-238 and ends with lead-206 (Figure 2).

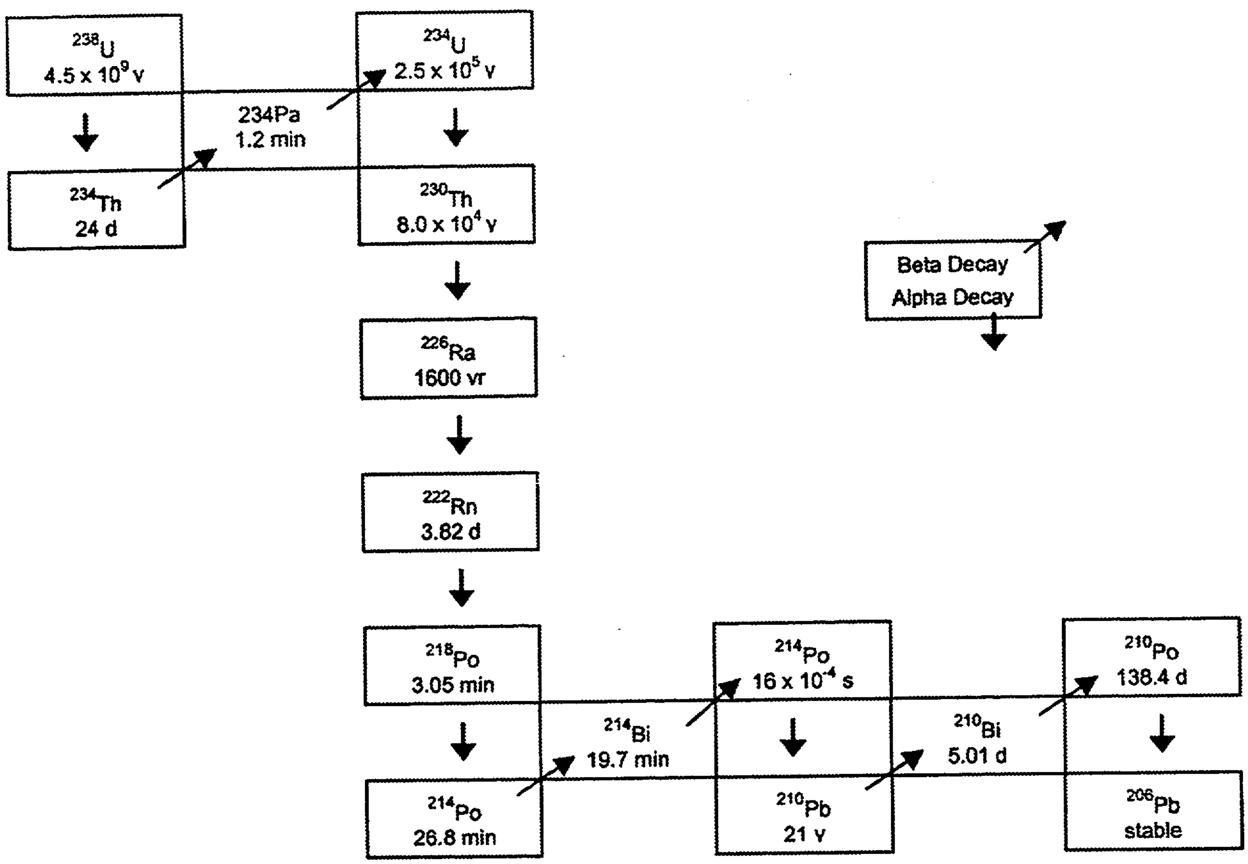


Figure 2: Principal Decay Scheme of the Uranium Series.

Half-life

Most radionuclides vary greatly in the frequency with which their atoms release radiation. Some radioactive materials, in which there are only infrequent emissions, tend to have a very long half-lives. Those radioactive materials that are very active, emitting radiation more frequently, tend to have comparably shorter half-lives. The length of time an atom remains radioactive is defined in terms of **half-lives**. Half-life is the amount of time required for a radioactive substance to lose half of its activity through the process of radioactive decay. Half-lives vary from millionths of a second to millions of years.

Interaction with Matter

Ionization

Through interactions with atoms, alpha, beta, and gamma radiation lose their energy. When these forms of radiation interact with any form of material, the energy they impart may cause atoms in that material to become **ions**, or charged particles. Normally, an atom has the same number of protons as electrons. Thus, the number of positive and negative charges cancel, and the atom is electrically neutral. When one or more electrons are removed an ion is formed. Ionization is one of the processes that may result in damage to biological systems.

Range and Shielding

Particulate and electromagnetic radiation each travel through matter differently because of their different properties. Alpha particles contain 2 protons and 2 neutrons, are relatively large, and carry an electrical charge of +2. Alpha particles are ejected from the nucleus of a radioactive atom at speeds ranging from 2,000 to 20,000 miles per second. However, due to its comparatively large size, an alpha particle usually does not travel very far before it loses most of its energy through collisions and interactions with other atoms. As a result, a sheet of paper or a few centimeters of air can easily stop alpha particles (Figure 3).

Beta particles are very small, and comparatively fast particles, traveling at speeds near the speed of light (186,000 miles per second). Beta particles have an electrical charge of either +1 or -1. Because they are so small and have a low charge, they do not collide and interact as often as alpha particles, so they can travel farther. Beta particles can usually travel through several meters of air, but may be stopped by a thin piece of metal or wood.

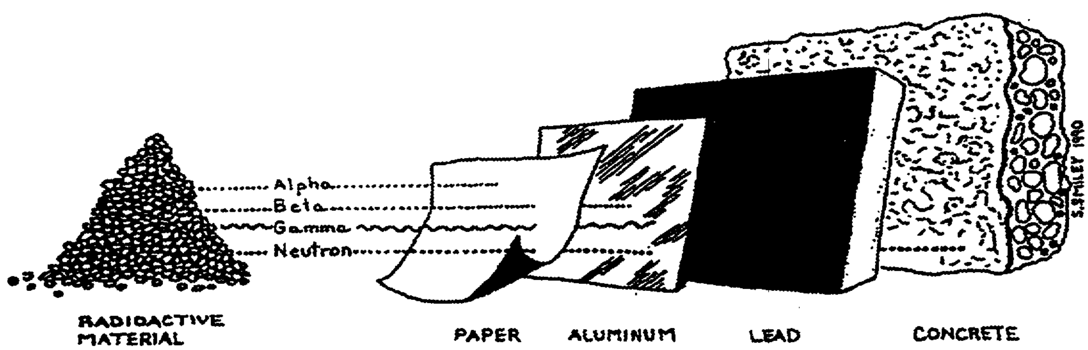


Figure 3: As radiation travels, it collides and interacts with other atoms and loses energy. Alpha particles can be stopped by a sheet of paper, and beta particles by a thin sheet of aluminum. Gamma radiation is shielded by highly dense materials such as lead, while hydrogenous materials (those containing hydrogen atoms), such as water and concrete, are used to stop neutrons.

Gamma rays are pure energy and travel at the speed of light. They have no measurable charge or mass, and generally travel much farther than alpha or beta particles before being absorbed. After repeated interactions, the gamma ray finally loses all of its energy and vanishes. The range of a gamma ray in air varies, depending on the ray's energy and interactions. Very high energy gamma radiation can travel a considerable distance, whereas low energy gamma radiation may travel only a few feet in air. Lead is used as shielding material for gamma radiation because of its density. Several inches of lead or concrete may be needed to effectively shield gamma rays.

Neutrons come from several sources, including the interactions of cosmic radiation with the earth's atmosphere and nuclear reactions within operating nuclear power reactors. However, neutrons are not of environmental concern since the neutron source at nuclear power stations is sealed within the containment building.

Because neutrons have no charge, they are able to pass very close to the nuclei of the material through which they are traveling. As a result, neutrons may be captured by one of these nuclei or they may be deflected. When deflected, the neutron loses some of its energy. After a series of these deflections, the neutron has lost most of its energy. At this point, the neutron moves about as slowly as the atoms of the material through which it is traveling, and is called a **thermal neutron**. In comparison, fast neutrons are much more energetic than thermal neutrons and have greater potential for causing damage to the material through which they travel. Fast neutrons can have from 200 thousand to 200 million times the energy of thermal neutrons.

Neutron shielding is designed to slow fast neutrons and absorb thermal neutrons. Neutron shielding materials commonly used to slow neutrons down are water or polyethylene. The shield is then completed with a material such as cadmium, to absorb the now thermal neutrons. At Davis-Besse, concrete is used to form an effective neutron shield because it contains water molecules and can be easily molded around odd shapes.

Quantities and Units of Measurement

There are several quantities and units of measurement used to describe radioactivity and its effects. Three terms of particular usefulness are **activity, absorbed dose,** and **dose equivalent.**

Activity: Curie

Activity is the number of atoms in a sample that disintegrate (decay) per unit of time. Each time an atom disintegrates, radiation is emitted. The **curie** (Ci) is the unit used to describe the activity of a material and indicates the rate at which the atoms of a radioactive substance are decaying. One curie indicates the disintegration of 37 billion atoms per second.

A curie is a unit of activity, not a quantity of material. Thus, the amount of material required to produce one curie varies. For example, one gram (1/28th of an ounce) of radium-226 is the equivalent of one curie of activity, but it would take 9,170,000 grams (about 10 tons) of thorium-232 to equal one curie.

Smaller units of the curie are often used, especially when discussing the low concentrations of radioactivity detected in environmental samples. For instance, the microcurie (uCi) is equal to one millionth of a curie, while the picocurie (pCi) represents one trillionth of a curie.

Absorbed Dose: Rad

Absorbed dose is a term used to describe the radiation energy absorbed by any material exposed to ionizing radiation, and can be used for both particulate and electromagnetic radiation. The

Rad (radiation absorbed dose) is the unit used to measure the absorbed dose. It is defined as the energy of ionizing radiation deposited per gram of absorbing material (1 Rad = 100 erg/gm). The rate of absorbed dose is usually given in Rad/hr.

If the biological effect of radiation is directly proportional to the energy deposited by radiation in an organism, the Rad would be a suitable measurement of the biological effect. However, biological effects depend not only on the total energy deposited per gram of tissue, but on how this energy is distributed along its path. Experiments have shown that certain types of radiation are more damaging per unit path of travel than are others. Thus, another unit is needed to quantify the biological damage caused by ionizing radiation.

Dose Equivalent: Rem

Biological damage due to alpha, beta, gamma and neutron radiation may result from the ionization caused by this radiation. Some types of radiation, especially alpha particles which cause dense local ionization, can result in up to 20 times the amount of biological damage for the same energy imparted as do gamma or X-rays. Therefore, a **quality factor** must be applied to account for the different ionizing capabilities of various types of ionizing radiation. When the quality factor is multiplied by the absorbed dose, the result is the **dose equivalent**, which is an estimate of the possible biological damage resulting from exposure to a particular type of ionizing radiation. The dose equivalent is measured in **rem (radiation equivalent man)**.

An example of this conversion from absorbed dose to dose equivalent uses the quality factor for alpha radiation, which is equal to 20. Thus, 1 Rad of alpha radiation is approximately equal to 20 rem. Beta and gamma radiation each have a quality factor of 1, therefore one Rad of either beta or gamma radiation is approximately equal to one rem. Neutrons have a quality factor ranging from 2 to 10. One rem produces the same amount of biological damage, regardless of the source. In terms of radiation, the rem is a relatively large unit. Therefore, a smaller unit, the **millirem**, is often used. One millirem (mrem) is equal to 1/1000 of a rem.

Deep Dose Equivalent (DDE)

Deep dose equivalent is the measurement of dose within the body, from sources of radiation that are external to the body. It is what is measured and recorded on thermoluminescent dosimeters (TLDs), film badges or other dosimeters. For example, at Davis-Besse or at any hospital that has x-ray equipment, you will see people wearing these devices. These instruments are worn to measure DDE.

Committed Effective Dose Equivalent (CEDE)

Committed effective dose equivalent is a measure of the dose received from any radioactive material taken into the body. It is calculated from the sum of the products of the committed dose equivalent to the organ or tissue multiplied by the organ or tissue-weighting factor. CEDE accounts for all the dose delivered during the entire time the radioactive material is in the body.

Total Effective Dose Equivalent (TEDE)

Total effective dose equivalent is the sum of the deep dose equivalent (for dose from sources external to the body) and the committed effective dose equivalent (for internal dose). Since they are both doses to the body, they are not tracked separately. The NRC limits occupational dose to a radiation worker to five rem (5000 mrem) TEDE per year.

Sources of Radiation

Background Radiation

Radiation did not begin with the nuclear power industry, and occurs naturally on earth. It is probably the most "natural" thing in nature. Mankind has always lived with radiation and probably always will. In fact, during every second of life, over 7,000 atoms undergo radioactive decay "naturally" in the body of the average adult. In addition, radioactive decay occurs naturally in soil, water, air and space. All these common sources of radiation contribute to the natural background radiation to which we are all exposed.

The earth is being showered by a steady stream of high-energy gamma rays and particulate radiation that come from space known as cosmic radiation. The atmosphere shields us from most of this radiation, but everyone still receives about 20 to 50 mrem each year from this source. The thinner air at higher altitudes provides less protection against cosmic radiation. People living at higher altitudes or flying in an airplane are exposed to even higher levels cosmic radiation. Radionuclides commonly found in the atmosphere as a result of cosmic ray interactions include beryllium-7, carbon-14, tritium (H-3), and sodium-22.

Another common naturally occurring radionuclide is potassium-40. About one-third of the external and internal dose from naturally occurring background radiation is attributed to this radioactive isotope of potassium.

The major source of background radiation is radon, a colorless, odorless, radioactive gas that results from the decay of radium-226, a member of the uranium-238 decay series. Since uranium occurs naturally in all soils and rocks, everyone is continuously exposed to radon and its daughter products. Radon is not considered to pose a health hazard unless it is concentrated in a confined area, such as buildings, basements or underground mines. Radon-related health concerns stem from the exposure of the lungs to this radioactive gas. Radon emits alpha radiation when it decays, which can cause damage to internal tissues when inhaled. As a result, exposure to the lungs is a concern, since the only recognized health effect associated with exposure to radon is an increased risk of lung cancer. This effect has been seen when radon is present at levels common in uranium mines. According to the National Council on Radiation Protection and Measurement (NCRP), over half of the radiation dose the average American receives is attributed to radon.

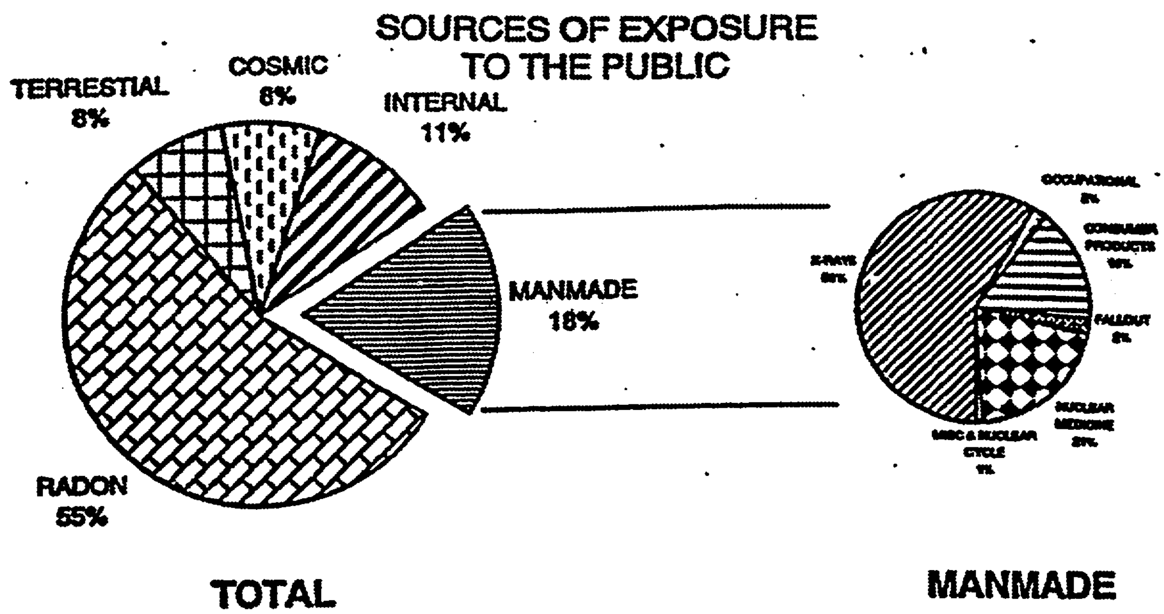


Figure 4: The most significant annual dose received by an individual of the public is that received from naturally occurring radon. A very small annual dose to the public results from producing electricity by nuclear power.

Further information on radon, its measurement, and actions to reduce the radon concentration in buildings can be obtained by contacting the state radon program office at the following address:

Ohio Department of Health, Bureau of Radiation Protection
P.O. Box 118, 35 East Chestnut Building 7th Floor
Columbus, Ohio 43216-0118
614) 481-5800
(800) 523-4439 (in Ohio Only)

The approximate average background radiation in this area (see Figure 4) is 300 mrem/year.

Man-Made Radiation

In addition to naturally occurring cosmic radiation and radiation from naturally occurring radioactivity, people are also exposed to man-made radiation. The largest sources of exposure include medical x-rays and radioactive pharmaceuticals. Small doses are also received from consumer products such as televisions, smoke detectors, and fertilizers. Fallout from nuclear weapons tests is another source of man-made exposure. Fallout radionuclides include strontium-90, cesium-137, and tritium. Less than one percent of the annual dose a member of the public receives is a result of having electricity generated by nuclear power.

Health Effects of Radiation

The effects of ionizing radiation on human health have been under study for more than 80 years. Scientists have obtained valuable knowledge through the study of laboratory animals that were exposed to radiation under extremely controlled conditions. However, it has been difficult to relate the biological effects of irradiated laboratory animals to the potential health effects on humans.

The effects of radiation on humans can be divided into two categories, somatic and genetic. Somatic effects are those which develop in the directly exposed individual, including an unborn child. Genetic effects are those which are observed in the offspring of the exposed individual.

Somatic effects can be divided further into acute and chronic effects. Acute effects develop shortly after exposure to large amount of radiation. Much study has been done with human populations that were exposed to ionizing radiation under various circumstances. These groups include the survivors of the atomic bomb, persons undergoing medical radiation treatment, and early radiologists, who accumulated large doses of radiation, unaware of the potential hazards.

Chronic effects are a result of exposure to radiation over an extended period of time. Examples of such groups are clock dial painters, who ingested large amounts of radium by "tipping" the paint brushes with their lips, and uranium miners, who inhaled large amounts of radioactive dust while mining pitchblende (uranium ore). The studies performed on these groups have increased our knowledge of the health effects from comparatively very large doses of radiation received over long periods of time.

Continuous exposure to low levels of radiation may produce somatic changes over an extended period of time. For example, someone may develop cancer from man-made radiation, background radiation, or some other source not related to radiation. Because all illnesses caused by low level radiation can also be caused by other factors, it is virtually impossible to determine individual health effects of low level radiation. Even though no effects have been observed at doses less than 50 rem, to be conservative, we assume the health effects resulting from low doses of radiation occur proportionally to those observed following large doses of radiation. Most radiation scientists agree that this assumption over-estimates the risks associated with a low-level radiation exposure. The effects predicted in this manner have never been actually observed in any individuals exposed to low level radiation. Therefore, the most likely somatic effect of low level radiation is believed to be a small increased risk of cancer.

Genetic effects could occur as a result of ionizing radiation interacting with the genes in the human cells. Radiation (as well as common chemicals) can cause physical changes or mutations in the genes. Chromosome fibers can break and rearrange, causing interference with the normal cell division of the chromosome by affecting their number and structure. A cell is able to rejoin the ends of a broken chromosome, but if there are two breaks close enough together in space and time, the broken ends from one break could join incorrectly with those from another. This could cause translocations, inversions, rings, and other types of structural rearrangements. When this happens, new mutated genes are created. Radiation is not the only mechanism by which such changes can occur. Spontaneous mutations and chemically induced mutations also have been observed. These mutated genes may be passed from parent to offspring. Viable mutations due to low level, low dose radiation have not been observed in humans.

Health Risks

While people may accept the risks inherent in their personal activities, such as smoking and driving to work each day, they are less inclined to accept the risk inherent in producing electricity. As with any industrial environment, it is not possible to guarantee a risk free environment. Thus, attention should be focused on taking steps to safeguard the public, on developing a realistic assessment of the risks, and on placing these risks in perspective. The perceptions of risk associated with exposure to radiation may have the greatest misunderstanding. Because people may not understand ionizing radiation and its associated risks, they may fear it. This fear is compounded by the fact that we cannot hear, smell, taste or feel ionizing radiation.

We do not fear other potentially hazardous things for which we have the same lack of sensory perception, such as radio waves, carbon monoxide, and small concentrations of numerous cancer-causing substances. These risks are larger and measurable compared to those presumed to be associated with exposure to low level, low dose radiation. Most of these risks are with us throughout our lives, and can be added up over a lifetime to obtain a total effect. Table 1 shows a number of different factors that decrease the average life expectancy of individuals in the United States.

Table 1: Risk Factors: Estimated Decrease in Average Life Expectancy

Overweight by 30%:		3.6 years
Cigarette smoking:	1 pack/day	7.0 years
	2 packs/day	10.0 years
Heart Disease:		5.8 years
Cancer:		2.7 years
City Living (not rural):		5.0 years
All operating commercial nuclear power plants totaled:		less than 12 minutes

Benefits of Nuclear Power

Nuclear power plays an important part in meeting today's electricity needs, and will continue to serve as an important source of electric energy well into the future. Today more than twenty percent of the electricity produced in the United States is from nuclear powered electrical generating stations.

Nuclear power offers several advantages over alternative sources of electric energy:

- nuclear power has an excellent safety record dating back to 1957, when the first commercial nuclear power station began operating,
- uranium, the fuel for nuclear power stations, is a relatively inexpensive fuel that is readily available in the United States,
- Nuclear power is the cleanest energy source for power stations that use steam to produce electricity. There are no greenhouse gases or acid gases produced when using nuclear fuel.

The following sections provide information on the fundamentals of how Davis-Besse uses nuclear fuel and the fission process to produce electricity.

Nuclear Power Production

Electricity is produced in a nuclear power station in the same way as in a fossil-fueled station with the exception of the source of heat. Heat changes water to steam that turns a turbine. In a fossil-fueled station, the fuel is burned in a furnace, which is also a boiler. Inside the boiler, water is turned into steam. In a nuclear station, a reactor that contains a core of nuclear fuel, primarily uranium, replaces the furnace. Heat is produced when the atoms of uranium are split, or fissioned, inside the reactor.

What is Fission?

A special force called the binding force holds the protons and neutrons together in the nucleus of the atom. The strength of this binding force varies from atom to atom. If the bond is weak enough, the nucleus can be split when bombarded by a free neutron (Figure 5). This causes the entire atom to split, producing smaller atoms, more free neutrons, and heat. In a nuclear reactor, a chain reaction of fission events provides the heat necessary to boil the water to produce steam.

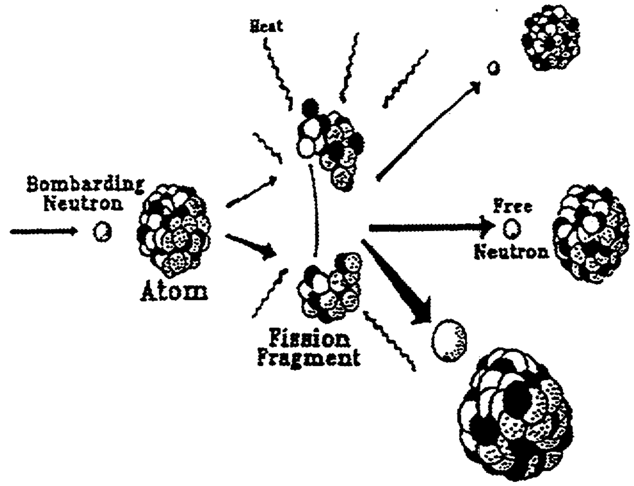


Figure 5: When a heavy atom, such as uranium-235 is split or fissioned, heat, free neutrons, and fission fragments result. The free neutrons can then strike neighboring atoms causing them to fission also. In the proper environment, this process can continue indefinitely in a chain reaction.

Nuclear Fuel

The fissioning of one uranium atom releases approximately 50 million times more energy than the combustion of a single carbon atom common to all fossil fuels. Since a single small reactor fuel pellet contains trillions of atoms, each pellet can release an extremely large amount of energy. The amount of electricity that can be generated from three small fuel pellets would require about 3.5 tons of coal or 12 barrels of oil to generate.

Nuclear fission occurs spontaneously in nature, but these natural occurrences cannot sustain themselves because the freed neutrons either are absorbed by non-fissionable atoms or quickly **decay**. In contrast, a nuclear reactor minimizes neutron losses, thus sustaining the fission process by several means:

- using fuel that is free of impurities that might absorb the free neutrons,
- enriching the concentration of the rarer fissionable isotope of uranium (U-235) relative to the concentration of U-238, a more common isotope that does not fission easily,
- slowing down neutron by providing a "moderator" such as water to increase the probability of fission.

Natural uranium contains less than one percent U-235 compared to the more abundant U-238 when it's mined. Before it can be economically used in a reactor, it is enriched to three to five percent U-235, in contrast to nuclear material used in nuclear weapons which is enriched to over 97 percent. Because of the low levels of U-235 in nuclear fuel, a nuclear power station **cannot** explode like a bomb.

After the uranium ore is separated from the earth and rock, it is concentrated in a milling process. After milling the ore to a granular form and dissolving out the uranium with acid, the uranium is converted to **uranium hexafluoride (UF_6)**. UF_6 is a chemical form of uranium that exists as a gas at temperatures slightly above room temperature. The UF_6 is then highly purified and shipped to an enrichment facility where **gaseous diffusion converters** increase the concentration of U-235. The enriched gaseous UF_6 is then converted into powdered **uranium dioxide (UO_2)**, a highly stable ceramic material. The UO_2 powder is put under high pressure to form **fuel pellets**, each about 5/8 inch long and 3/8 inch in diameter. Approximately five pounds of these pellets are placed into a 12-foot long metal tube made of zirconium alloy. The tubes constitute the **fuel cladding**. The fuel cladding is highly resistant to heat, radiation, and corrosion. When the tubes are filled with fuel pellets, they are called **fuel rods**.

The Reactor Core

Two hundred eight fuel rods comprise a single **fuel assembly**. The **reactor core** at Davis-Besse contains 177 of these fuel assemblies, each approximately 14 feet tall and 2,000 pounds in weight. In addition to the fuel rods, the fuel assembly also contains 16 vacant holes for the insertion of **control rods**, and one vacant hole for an **incore-monitoring probe**. This probe monitors temperature and neutron levels in the fuel assembly. The Davis-Besse reactor vessel, which contains all the fuel assemblies, weighs 838,000 pounds, has a diameter of 14 feet, is 39 feet high, and has steel walls that are 8 ½ inches thick.

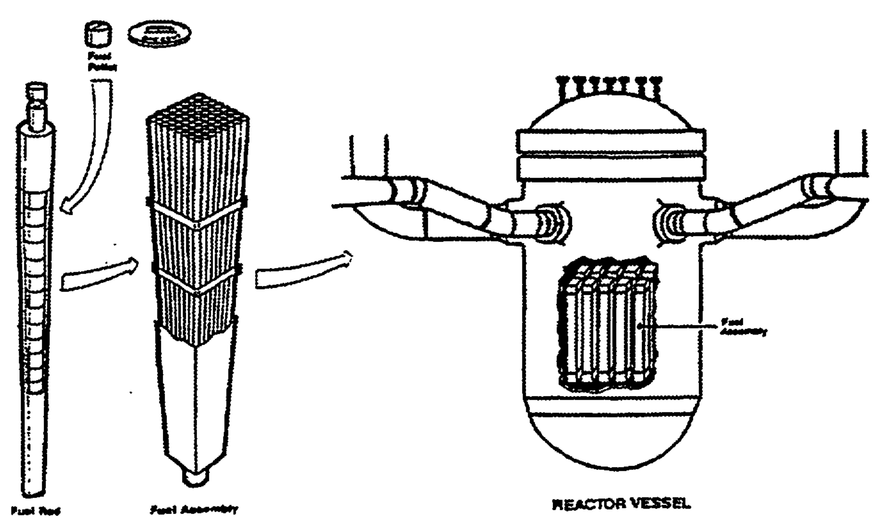


Figure 6: The reactor core at Davis-Besse contains 177 fuel assemblies. Each assembly contains 208 fuel rods. Each fuel rod is filled with approximately five pounds of fuel pellets, each pellet is approximately 3/8 inch in diameter and 5/8 inch long.

Fission Control

Raising or lowering control rod assemblies into the reactor core controls the fission rate. Each assembly consist of "fingers" containing silver, indium, and cadmium metals that absorb free neutrons, thus disrupting the fission chain reaction. When control rod assemblies are slowly withdrawn from the core, fissioning begins and heat is produced. If the control rod assemblies are inserted rapidly into the reactor core, as during a plant "trip", the chain reaction ceases. A slower acting (but more evenly distributed) method of fission control is achieved by the addition of a **neutron poison** to the reactor coolant water. At Davis-Besse, high-purity boric acid is concentrated or diluted in the coolant to achieve the desired level of fission. Boron-10 readily absorbs free neutrons, forming boron-11, removing the absorbed neutrons from the chain reaction.

Reactor Types

Virtually all of the commercial reactors in this country are either **boiling water reactors (BWRs)** or **pressurized water reactors (PWRs)**. Both types are also called **light water reactors (LWRs)** because their coolant, or medium to transfer heat, is ordinary water, which contains the light isotope of hydrogen. Some reactors use the heavy isotope of hydrogen (deuterium) in the reactor coolant. Such reactors are called **heavy water reactors (HWRs)**.

In BWRs, water passes through the core and boils into steam. The steam passes through separators which remove water droplets. The steam then travels to dryers before entering the turbine. After passing though the turbine the steam is condensed back into water and returns to the core to repeat the cycle.

In PWRs, the reactor water or coolant is pressurized to prevent it from boiling. The reactor water is then pumped to a **steam generator** (heat exchanger) where its heat is transferred to a secondary water supply. The secondary water inside the generator boils into steam, which is then used to turn the turbine. This steam is then condensed back into water and returned to the steam generator. Davis-Besse uses a PWR design.

The following paragraphs describe the various systems illustrated in Figure 7. Major systems in the Davis-Besse Station are assigned a different color in the figure.

Davis-Besse Nuclear Power Station
Unit No. 1

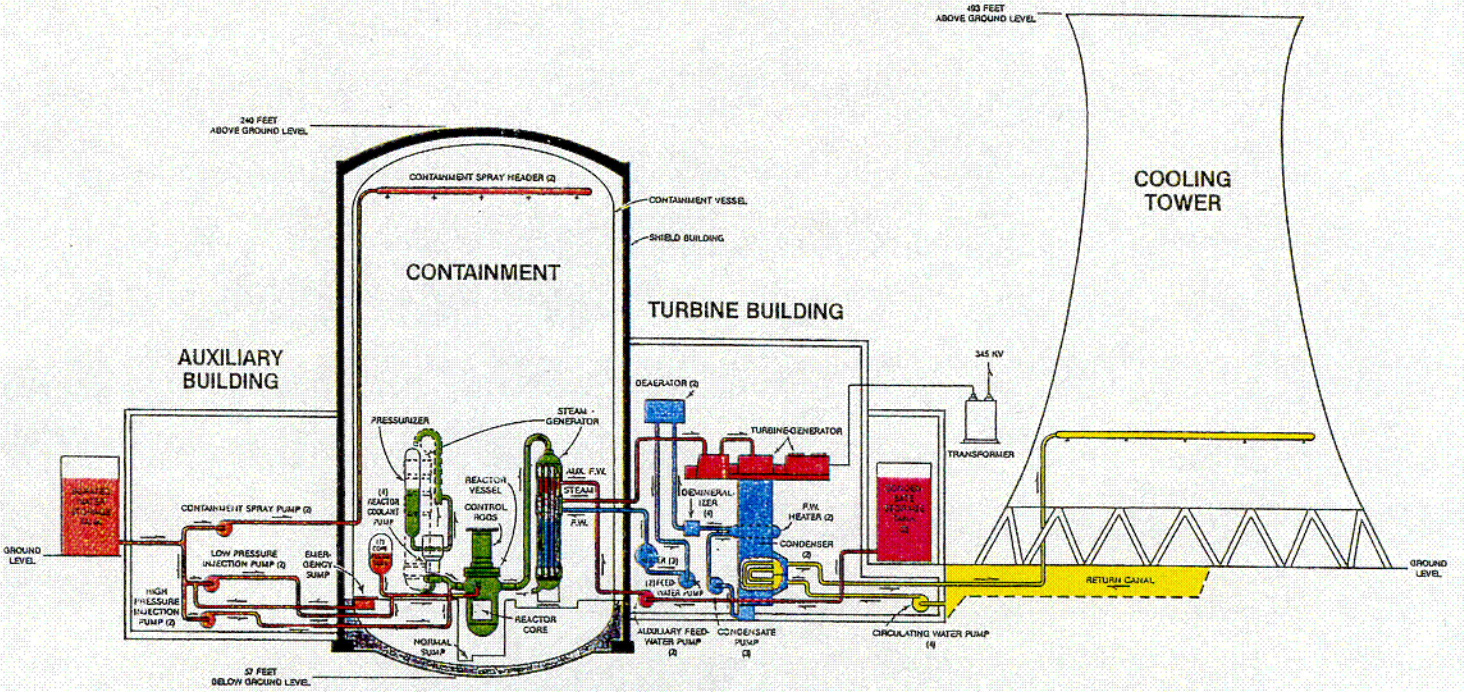


Figure 7: Station Systems

C02

Station Systems

Containment Building and Fission Product Release Barriers

The **containment building** houses the reactor vessel, the pressurizer, two steam generators, the reactor coolant pumps and reactor coolant system piping. The building is constructed of an inner 1 –1/2 inch thick steel liner or **containment vessel**, and the **shield building** with steel reinforced concrete walls 2 feet thick. The shield building protects the containment vessel from a variety of environmental factors and provides an area for a **negative pressure boundary** around the steel containment vessel. In the event that the integrity of the containment vessel is compromised (e.g., a crack develops), this negative pressure boundary ensures that any airborne radioactive contamination present in the containment vessel is prevented from leaking out into the environment. This is accomplished by maintaining the pressure inside the shield building lower than that outdoors, thus forcing clean outside air to leak in, while making it impossible for the contaminated air between the containment vessel and the shield building to leak out. The containment vessel is the third in a **series of barriers** that prevent the release of fission products in the unlikely event of an accident. The first barrier to the release of fission products is the fuel cladding itself. The second barrier is the walls of the primary system, i.e. the reactor vessel, steam generator and associated piping.

The Steam Generators

The **steam generators** perform the same function as a boiler at a fossil-fueled power station. The steam generator uses the heat of the primary coolant inside the steam generator tubes to boil the secondary side **feedwater** (secondary coolant). Fission heat from the reactor core is transferred to the steam generator in order to provide the steam necessary to drive the turbine. However, heat must also be removed from the core even after reactor shutdown in order to prevent damage to the fuel cladding. Therefore, pumps maintain a continuous flow of coolant through the reactor and steam generator. **Primary loop water** (green in Figure 7) exits the reactor at approximately 606°F, passes through the steam generator, transferring some of its heat energy to the **secondary loop water** (blue in Figure 7) without actually coming in contact with it. Primary coolant water exits the steam generator at approximately 558°F to be circulated back into the reactor where it is again heated to 606°F as it passes up through the fuel assemblies. Under ordinary conditions, water inside the primary system would boil long before it reached such temperatures. However, it is kept under a pressure of approximately 2,200 pounds-per-square-inch (psi) at all times. This prevents the water from boiling and is the reason the reactor at Davis-Besse is called a Pressurized Water Reactor. Secondary loop water enters the base of the steam generator at approximately 450°F and under 1,100 psi pressure. At this pressure, the water can easily boil into steam as it passes over the tubes containing the primary coolant water.

Both the primary and the secondary coolant water are considered **closed loop systems**. This means that they are designed not to come in physical contact with one another. Rather, the cooling water in each loop transfers heat energy by **convection**. Convection is a method of **heat transfer** that can occur between two fluid media. It is the same process by which radiators are used to heat homes. The water circulating inside the radiator is separated from the air (a "fluid" medium) by the metal piping.

The Turbine - Generator

The turbine, main generator, and the condenser are all housed in what is commonly referred to as the **Turbine Building**. The purpose of the **turbine** is to convert the **thermal energy** of the steam produced in the steam generator (referred to as **main steam**, red in Figure 7) to **rotational energy** of the turbine generator shaft. The turbine at Davis-Besse is actually composed of one six-stage high-pressure turbine and two seven-stage low-pressure turbines aligned on a common shaft. A **turbine stage** refers to a set of blades. Steam enters at the center of each turbine and moves outward along the shaft in opposite directions through each successive stage of blading. As the steam passes over the turbine blades, it loses pressure. Thus, the blades must be proportionally larger in successive stages to extract enough energy from the steam to rotate the shaft at the correct speed.

The purpose of the **main generator** is to convert the rotational energy of the shaft to **electrical energy** for commercial usage and support of station systems. The main generator is composed of two parts, a stationary **stator** that contains coils of copper conductors, and a **rotor** that supplies a rotating magnetic field within the coils of the stator. Electrical current is generated in the stator portion of the main generator. From this point, the electric current passes through a series of **transformers** for transmission and use throughout northern Ohio.

The Condenser

After the spent steam in the secondary loop (blue in Figure 7) passes through the high and low pressure turbines, it is collected in a cavernous **condenser** several stories tall and containing more than 70,000 small tubes. **Circulating water** (yellow in Figure 7) goes to the **cooling tower** after passing through the tubes inside the condenser. As the steam from the low-pressure turbines passes over these tubes, it is cooled and condensed. The condensed water is then purified and reheated before being circulated back into the steam generator again in a closed loop system. Circulating water forms the third (or **tertiary**) and final loop of cooling water used at the Davis-Besse Station.

Similar to the primary to secondary interface, the secondary to tertiary interface is based on a closed loop design. The circulating water is able to cool the steam in the condenser, without ever actually coming in contact with it, by the process of convection. Even in the event of a primary to secondary leak, the water vapor exiting the Davis-Besse cooling tower would remain non-radioactive. Closed loops are an integral part of the design of any nuclear facility. This design feature greatly reduces the chance of environmental impact from station operation.

The Cooling Tower

The Cooling Tower at Davis-Besse is easily the most noticeable feature of the plant. The tower stands 493 feet high and the diameter of the base is 411 feet. Two nine-foot diameter pipes circulate 480,000 gallons of water per minute to the tower. Its purpose is to recycle water from the condenser by cooling and returning it.

After passing through the condenser, the Circulating Water has warmed to approximately 100°F. In order to cool the water back down to around 70°F, the Circulating Water enters the Cooling Tower about 40 feet above the ground. The water is sprayed evenly over a series of baffles called **fillsheets,** which are suspended vertically in the base of the tower. A natural draft of air blowing upward through these baffles cools the water by the process of **evaporation**. The evaporated water exits the top of the Cooling Tower as **water vapor**.

As much as 10,000 gallons of water per minute are lost to the atmosphere via the Cooling Tower. Even so, approximately 98 percent of the water drawn from Lake Erie for station operation can be recycled through the Cooling Tower for reuse. A small portion of the Circulating Water is discharged back to Lake Erie at essentially the same temperature it was withdrawn earlier. The slightly warmer water has no adverse environmental impact on the area of lake surrounding the discharge point.

Miscellaneous Station Safety Systems

The orange system in Figure 7 is part of the **Emergency Core Cooling System (ECCS)** housed in the **Auxiliary Building** of the station. The ECCS consists of three overlapping means of keeping the reactor core covered with water, in the unlikely event of a Loss of Coolant Accident (LOCA), thereby protecting the fuel cladding barrier against high temperature failure. Depending upon the severity of the loss of pressure inside the primary system, the ECCS will automatically channel borated water into the reactor by using **high-pressure injection pumps, a core flood tank,** or **low-pressure injection pumps**. Borated water can also be sprayed from the ceiling of the containment vessel to cool and condense any steam that escapes the primary system.

The violet system illustrated in Figure 7 is responsible for maintaining the primary coolant water in a liquid state. It accomplishes this by adjusting the pressure inside the primary system. Heaters inside the **Pressurizer** turn water into steam. This steam takes up more space inside the Pressurizer, thereby increasing the overall pressure inside the primary system. The Pressurizer is equipped with spray heads that shower cool water over the steam in the unit. In this case, the steam condenses and the overall pressure inside the primary system drops. The **Quench Tank** pictured in Figure 8 is simply where excess steam is directed and condensed for storage.

The scarlet system in Figure 7 is part of the **Auxiliary Feedwater System**, a key safety system in event the main feedwater supply (blue in Figure 7) to the Steam Generator is lost. Following a reactor shutdown, the Auxiliary Feedwater System can supply water to the Steam Generators from the **Condensate Storage Tanks**. The Auxiliary Feedwater System is housed in the Turbine Building along with the Turbine, Main Generator, and the Condenser.

Reactor Safety and Summary

Nuclear power plants are inherently safe, not only by the laws of physics, but by design. Nuclear power plants cannot explode like a bomb because the concentration of fissionable material is far less than is necessary for such a nuclear explosion. Also, many safety features are equipped with several backup systems to ensure that any possible accident would be prevented from causing a serious health or safety threat to the public, or serious impact on the local environment. Davis-Besse, like all U.S. nuclear units, has many overlapping, or redundant safety features. If one system should fail, there are still back-up systems to assure the safe operation of the Station. During normal operation, the **Reactor Control System** regulates the power output by adjusting the position of the control rods. The reactor can be automatically shut down by a separate **Reactor Protection System** that causes all the control rod assemblies to be quickly and completely inserted into the reactor core, stopping the chain reaction. To guard against the possibility of a Loss of Coolant Accident, the Emergency Core Cooling System is designed to pump reserve water into the reactor automatically if the reactor coolant pressure drops below a predetermined level.

The Davis-Besse Nuclear Power Station was designed, constructed, and operates to produce a reliable, safe, and environmentally sound source of electricity.

Radioactive Waste

Many of the activities we depend on in our everyday lives produce radioactive waste by-products. Nuclear energy, industrial processes, and medical treatments are some of these activities. These by-products are managed and disposed of under strict requirements set by the federal government. With the exception of used nuclear fuel assemblies, these by-products produced at commercial power plants are referred to as low level radioactive waste.

Low Level Radioactive Waste

Low level radioactive waste consists mainly of ordinary trash and other items that have become contaminated with radioactive materials. It includes plastic gloves and other protective clothing, machine parts and tools, medical and laboratory equipment, filters, resins, and general scrap.

The radioactive material in low level radioactive waste emits the same types of radiation that naturally occurring radioactive materials tend to emit. Most low level radioactive waste "decays" to background levels of radioactivity in months or years. Nearly all of it diminishes to stable materials in less than 300 years.

Davis-Besse presently ships low level radioactive waste to a South Carolina disposal facility located at Barnwell, South Carolina. This facility was closed to out-of-compact generators from July 1, 1994 to July 1, 1996. It was reopened to all generators on July 1, 1996. At this time, Davis-Besse resumed shipping of low-level radioactive waste to the facility. Davis-Besse has the capacity to store low-level waste produced on site in the Low Level Radioactive Waste Storage Facility (LLRWSF) for several years, should the Barnwell facility close again.

High Level Nuclear Waste

Like any industrial or scientific process, nuclear energy does produce waste. The most radioactive is defined as "high-level" waste (because it has high levels of radioactivity). Ninety-nine percent of high-level waste from nuclear plants is used nuclear fuel. The fuel undergoes certain changes during fission. Most of the fragments of fission, pieces that are left over after the atom is split, are radioactive. After a period of time, the fission fragments trapped in the fuel assemblies reduce the efficiency of the chain reaction. Every 18 to 24 months, the oldest fuel assemblies are removed from the reactor and replaced with fresh fuel.

High-level nuclear waste volumes are small. Davis-Besse produces about 30 tons of used fuel every 24 months. All the used fuel produced by all America's nuclear energy plants since the first plant started operating over 30 years ago would cover an area the size of a football field about five yards deep. All of America's nuclear plants combined produce only 3,000 tons of used fuel each year. By contrast, the U.S. produces about 300,000,000 tons of chemical waste annually. Also, nuclear waste slowly loses its radioactivity, but some chemical waste remains hazardous indefinitely.

Davis-Besse presently stores most of its used fuel in a steel-lined water-filled concrete vault inside the plant. The Department of Energy is charged with constructing a permanent high-level waste repository for all of the nation's nuclear plants. By law, the Department of Energy was supposed to accept fuel from utilities by the end of 1998. Currently, Yucca Mountain, Nevada, is being considered as a possible site. Until the permanent DOE site is developed, nuclear plants will be responsible for the continued safe storage of high-level waste. At Davis-Besse, the fuel pool reached its capacity in 1996. At the end of 1996, Davis-Besse began the process of moving the older fuel assemblies that no longer require water cooling to air-cooled concrete shielded canisters. These will remain onsite until the Department of Energy facilities are ready to receive them. Dry fuel storage is already used in many countries, including Canada, and in the U.S. at nuclear plants in Arkansas, Colorado, Maryland, Michigan, Minnesota, Virginia, Wisconsin and South Carolina. Figure 8 illustrates the Dry Fuel Storage module arrangement at Davis-Besse.

In 2001, work began to increase the storage capacity of the Spent Fuel Pool. The pool remains the same size, however, removing old storage racks and replacing them with new ones changed the configuration of storage, and allows the site to safely hold all the fuel used during its 40 year expected life. This modification was completed in April of 2002.

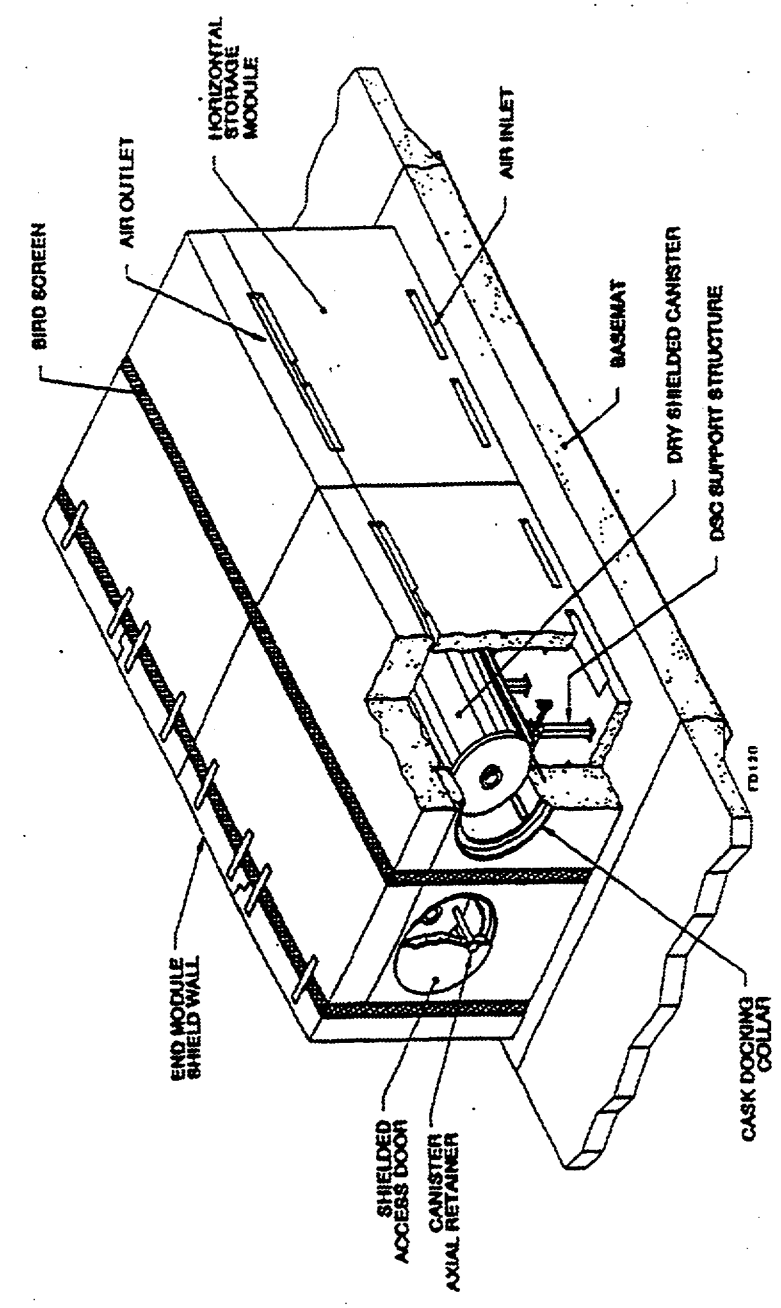


Figure 8: Dry Fuel Storage Module Arrangement

Description of the Davis-Besse Site

The Davis-Besse site is located in Carroll Township of Ottawa County, Ohio. It is on the south-western shore of Lake Erie, just north of the Toussaint River. The site lies north and east of Ohio State Route 2, approximately 10 miles northwest of Port Clinton, 7 miles north of Oak Harbor, and 25 miles east of Toledo, Ohio (Figure 9).

This section of Ohio is flat and marshy, with maximum elevations of only a few feet above the level of Lake Erie. The area originally consisted of swamp forest and marshland, rich in wildlife but unsuitable for settlement and farming. During the nineteenth century, the land was cleared and drained, and has been farmed successfully since. Today, the terrain consists of farmland with marshes extending in some places for up to two miles inland from the Sandusky Lake Shore Ridge.

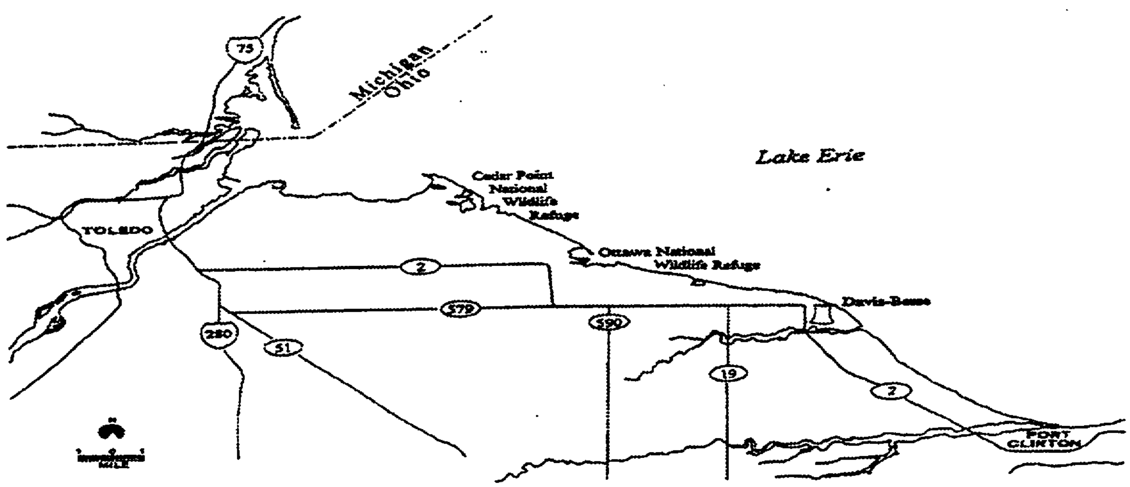


Figure 9: Davis-Besse is near Oak Harbor, Port Clinton, and the Ottawa National Wildlife Refuge.

The Davis-Besse site is mainly comprised of marshland, with a small portion consisting of farm-land. The marshes are part of a valuable ecological resource, providing a breeding ground for a variety of wildlife, and a refuge for migratory birds. The site includes a tract known as Navarre Marsh, which was acquired from the U.S. Bureau of Sport Fisheries and Wildlife, Department of the Interior. In 1971, Toledo Edison purchased the 188-acre Toussaint River Marsh. The Tous-saint River Marsh is contiguous with the 610-acre Navarre Marsh section of the Ottawa National Wildlife Refuge.

The immediate area near Davis-Besse is sparsely populated. Ottawa County had a population of 40,985 according to the 2000 Census. The incorporated communities nearest to Davis-Besse are:

- Port Clinton - 10 miles southeast, population 6,391
- Oak Harbor - 7 miles south, population 2,841
- Rocky Ridge - 7 miles west southwest, population 389
- Toledo (nearest major city) - 25 miles west, population 313,619

There are some residences along the lakeshore used mainly as summer homes. However, the major resort area of the county is farther east, around Port Clinton, Lakeside, and the Bass Islands.

The majority of non-marsh areas around the Davis-Besse site are used for farming. The major crops include soybeans, corn, wheat, oats, hay, fruits and vegetables. Meat and dairy animals are not major sources of income in the area. The main industries within five miles of the site are located in Erie Industrial Park, about four miles southeast of the station.

Most of the remaining marshes in the area have been maintained by private hunting clubs, the U.S. Fish and Wildlife Service, and the Ohio Department of Natural Resources, Division of Wildlife. The State of Ohio Department of Natural Resources operates many wildlife and recreational areas within 10 miles of the Station. These include Magee Marsh, Turtle Creek, Crane Creek State Park, and the Ottawa National Wildlife Refuge. Magee Marsh and Turtle Creek lie between three and six miles WNW of the Station. Magee Marsh is a wildlife preserve that allows public fishing, nature study, and a controlled hunting season. Turtle Creek, a wooded area at the southern end of Magee Marsh, offers boating and fishing. Crane Creek State Park is adjacent to Magee Marsh and is a popular picnicking, swimming, and fishing area. The Ottawa National Wildlife Refuge lies four to nine miles WNW of the Site, immediately west of Magee Marsh.

References

1. "Basic Radiation Protection Criteria," Report No. 39, National Council on Radiation Protection and Measurement, Washington, D.C. (January 1971).

2. "Cesium-137 from the Environment to Man: Metabolism and Dose," Report No. 52, National Council on Radiation Protection and Measurements, Washington, D.C. (January 1977).

3. Deutch, R., "Nuclear Power, A Rational Approach," Fourth edition, GP Courseware, Inc., Columbia, MD. (1987).

4. Eisenbud, M., "Environmental Radioactivity," Academic Press, Inc., Orlando, FL. (1987).

5. "Environmental Radiation Measurements," Report No. 50, National Council on Radiation Protection and Measurements, Washington, D.C. (December 1976).

6. "Exposure of the Population in the United States and Canada from Natural Background Radiation," Report No. 94, National Council on Radiation Protection and Measurements, Washington, D.C. (December 1987).

7. "Health Effects of Exposure to Low Levels of Ionizing Radiation: BEIR V," Committee on the Biological Effects of Ionizing Radiations, Board on Radiation Effects Research Commission on Life Sciences, National Research Council, National Academy Press, Washington, D.C. (1990).

8. Hendee, William R., and Doege, Theodore C., "Origin and Health Risks of Indoor Radon," Seminars in Nuclear Medicine, Vol. XVIII, No. 1, American Medical Association, Chicago, IL. (January 1987).

9. Hurley, P., "Living with Nuclear Radiation," University of Michigan Press, Ann Arbor, MI. (1982).

10. "Indoor Air Quality Environmental Information Handbook: Radon," prepared for the United States Department of Energy, Assistant Secretary for Environment, Safety and Health, by Mueller Associated, Inc., Baltimore, MD. (January 1986).

11. Introduction to Davis-Besse Nuclear Power Station Plant Technology, July 1992, Rev. 4, Pg.2-9.

12. "Ionizing Radiation Exposure of the Population of the United States," Report No. 93, National Council on Radiation Protection and Measurements, Washington, D.C. (September 1987).

13. "Natural Background Radiation in the United States," Report No. 45, National Council on Radiation Protection and Measurements, Washington, D.C. (November 1975).

14. "Nuclear Energy Emerges from 1980's Poised for New Growth," U.S. Council for Energy Awareness, Washington, D.C. (1989).

15. "Nuclear Power: Answers to Your Questions," Edison Electric Institute, Washington, D.C. (1987).

16. "Public Radiation Exposure from Nuclear Power Generation in the United States," Report No. 92, National Council on Radiation Protection and Measurement, Washington, D.C. (December 1987).

17. "Radiation Protection Standards," Department of Environmental Sciences and Physiology and the Office of Continuing Education, Harvard School Of Public Health, Boston, MA. (July 1989).

18. Radiological Environmental Monitoring Report for Three Mile Island Station," GPU Nuclear Corporation, Middletown, PA. (1985).

19. "Sources, Effects and Risk of Ionizing Radiation," United Nations Scientific Committee on the Effects of Atomic Radiation, 1988 Report to the General Assembly, United Nations, New York (1988).

20. "Standards for Protection Against Radiation," Title 10, Part 20, Code of Federal Regulation, Washington, D.C. (1988).

21. "Domestic Licensing of Production and Utilization Facilities," Title 10, Part 50, Code of Federal Regulations, Washington, D.C. (1988).

22. "Environmental Radiation Protection Standard for Nuclear Power Operations," Title 40, Part 190, Code of Federal Regulations, Washington, D.C. (1988).

23. "Tritium in the Environment," Report No. 62, National Council on Radiation Protection and Measurement, Washington, D.C. (March 1979).

24. Site Environmental Report, Fernald Environmental Management Project, United States Department of Energy (June 1993).

25. " Exposure from the Uranium Series with Emphasis on Radon and it's daughters" Report No. 77, National Council on Radiation Protection and Measurements, Washington, D.C. (1984).

26. "Evaluation of Occupational and Environmental Exposures to Radon and Radon daughter in the United States, " Report No. 78, National Council on Radiation Protection and Measurements, Washington, D.C. (1984).

Radiological Environmental Monitoring Program

Radiological Environmental Monitoring Program

Introduction

The **Radiological Environmental Monitoring Program (REMP)** was established at Davis-Besse for several reasons: to provide a supplementary check on the adequacy of containment and effluent controls, to assess the radiological impact of the Station's operation on the surrounding area, and to determine compliance with applicable radiation protection guides and standards. The REMP was established in 1972, five years before the Station became operational. This **preoperational surveillance program** was established to describe and quantify the radioactivity, and its variability, in the area prior to the operation of Davis-Besse. After Davis-Besse became operational in 1977, the **operational surveillance program** continued to measure radiation and radioactivity in the surrounding areas.

A variety of environmental samples are collected as part of the REMP at Davis-Besse. The selection of sample types is based on the established critical pathways for the transfer of radionuclides through the environment to humans. The selection of sampling locations is based on sample availability, local meteorological and hydrological characteristics, local population characteristics, and land usage in the area of interest. The selection of sampling frequencies for the various environmental media is based on the radionuclides of interest, their respective half-lives, and their effect in both biological and physical environments.

A description of the REMP at Davis-Besse is provided in the following section. In addition, a brief history of analytical results for each sample type collected since 1972, and a more detailed summary of the analyses performed during this reporting period, is also provided.

Preoperational Surveillance Program

The federal government requires nuclear facilities to conduct radiological environmental monitoring prior to constructing the facility. This preoperational surveillance program is for the collection of data needed to identify critical pathways, including selection of radioisotope and sample media combinations for the surveillance conducted after facility operation begins. Radiochemical analyses performed on the samples should include both nuclides expected to be released during facility operation, and typical fallout radionuclides and natural background radioactivity. All environmental media with a potential to be affected by facility operation, as well as those media directly in the critical pathways, should be sampled during the preoperational phase of the environmental surveillance program.

The preoperational surveillance design, including nuclide/media combinations, sampling frequencies and locations, collection techniques, and radioanalyses performed, should be carefully considered and incorporated in the design of the operational surveillance program. In this manner, data can be compared in a variety of ways (for example: from year to year, location to location, etc.) in order to detect any radiological impact the facility has on the surrounding environment. Data collection during the preoperational phase should be planned to provide a comprehensive database for evaluating any future changes in the environment surrounding the nuclear facility.

Davis-Besse began its preoperational environmental surveillance program five years before the Station began producing power for commercial use in 1977. Data accumulated during those early years provide an extensive database from which Station personnel are able to identify trends in the radiological characteristics of the local environment. The environmental surveillance program at Davis-Besse will continue after the Station has reached the end of its economically useful life and decommissioning has begun.

Operational Surveillance Program Objectives

The operational phase of the environmental surveillance program at Davis-Besse was designed with the following objectives in mind:

- to fulfill the obligations of the radiological surveillance sections of the Station's Technical Specifications and Offsite Dose Calculation Manual
- to determine whether any significant increase in the concentration of radionuclides in critical pathways occurs
- to identify and evaluate the buildup, if any, of radionuclides in the local environment, or any changes in normal background radiation levels
- to verify the adequacy of Station controls for the release of radioactive materials

Quality Assurance

An important part of the environmental monitoring program at Davis-Besse is the **Quality Assurance (QA) Program**, which is conducted in accordance with the guidelines specified in NRC Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs." The QA Program is designed to identify possible deficiencies in the REMP so that corrective actions can be initiated promptly. Davis-Besse's Quality Assurance program also provides confidence in the results of the REMP through:

- performing regular audits (investigations) of the REMP, including a careful examination of sample collection techniques and record keeping;
- performing audits of contractor laboratories which analyze the environmental samples,
- requiring analytical contractor laboratories to participate in the United States Environmental Protection Agency Cross-Check Program,
- requiring analytical contractor laboratories to split samples for separate analysis followed by a comparison of results,
- splitting samples prior to analysis by independent laboratories, and then comparing the results for agreement, and, finally,

- requiring analytical contractor laboratories to perform in-house spiked sample analyses.

Quality Assessment audits and inspections of the Davis-Besse REMP are performed by the FirstEnergy Nuclear Operating Company QA Department and the NRC. In addition, the NRC and the Ohio Department of Health (ODH) also perform independent environmental monitoring in the vicinity of Davis-Besse. The types of samples collected and the sampling locations used by the NRC and ODH were incorporated in Davis-Besse's REMP. Hence, the analytical results from the different programs can be compared. This practice of comparing results from identical samples, collected and analyzed by different parties, provides a valuable tool to verify the quality of the laboratories analytical procedures and the data generated.

In 1987, environmental sampling personnel at Davis-Besse incorporated their own QA program into the REMP. Duplicate samples, called quality control samples, were collected at several locations. These duplicate samples were assigned different identification numbers than the numbers assigned to the routine samples. This ensured that the analytical laboratory would not know the samples were identical. The laboratory results from analysis of the quality control samples and the routine samples could then be compared for agreement. Quality control sampling has been integrated into the program and has become an important part of the REMP since 1987. Quality control sampling locations are changed frequently in order to duplicate as many sampling locations as possible, and to ensure the contractor laboratory has no way of correctly pairing a quality control sample with its routine sample counterpart.

Program Description

The Radiological Environmental Monitoring Program (REMP) at Davis-Besse is conducted in accordance with Title 10, Code of Federal Regulations, Part 50; Regulatory Guide 4.8; the Davis-Besse Nuclear Power Station Operating License, Appendix A (Technical Specifications); the Davis-Besse Offsite Dose Calculation Manual (ODCM) and Station Operating Procedures. Samples are collected weekly, monthly, quarterly, semiannually, or annually, depending upon the sample type and nature of the radionuclides of interest. Environmental samples collected by Davis-Besse personnel are divided into four general types:

- **atmospheric** -- including samples of airborne particulates and airborne radio-iodine
- **terrestrial** -- including samples of milk, groundwater, broad leaf vegetation, fruits, animal/wildlife feed, soil, and wild and domestic meat
- **aquatic** -- including samples of treated and untreated surface water, fish, and shoreline sediments
- **direct radiation** -- measured by thermoluminescent dosimeters

All environmental samples are labeled using a sampling code. Table 2 provides the sample codes and collection frequency for each sample type.

REMP samples are collected onsite and offsite up to 25 miles away from the Station. Sampling locations may be divided into two general categories: indicator and control. Indicator locations are those which would be most likely to display the effects caused by the operation of Davis-

Besse, and are located within five miles of the station. Control locations are those which should be unaffected by Station operations, and are more than five miles from the Station. Data from indicator locations are compared with data from the control locations. This comparison allows REMP personnel to take into account naturally-occurring background radiation or fallout from weapons testing in evaluating any radiological impact Davis-Besse has on the surrounding environment. Data from indicator and control locations are also compared with preoperational data to determine whether significant variations or trends exist.

Since 1987 the REMP has been reviewed and modified to develop a comprehensive sampling program adjusted to the current needs of the utility. Modifications have included additions of sampling locations above the minimum amount required in the ODCM and increasing the number of analyses performed on each sample. Besides adding new locations, duplicate or Quality Control (QC) sample collection was initiated to verify the accuracy of the lab analyzing the environmental samples. These additional samples are referred to as the REMP Enhancement Samples. Approximately 2000 samples were collected and over 2300 analyses were performed during 2001. In addition, 15% of the sampling locations were quality control sampling locations. Table 3 shows the number of the sampling location and number collected for each type.

Table 2: Sample Codes and Collection Frequencies

Sample Type	Sample Code	Collection Frequency
Airborne Particulate	AP	Weekly
Airborne Iodine	AI	Weekly
Thermoluminescent Dosimeter	TLD	Quarterly, Annually
Milk	MIL	Monthly (semi-monthly during grazing season)
Groundwater	WW	Quarterly
Broadleaf Vegetation	BLV	Monthly (when available)
Surface Water - Treated	SWT	Weekly
Surface Water - Untreated	SWU	Weekly (lake water – monthly in summer)
Fish	FIS	Annually
Shoreline Sediment	SED	Semiannually
Soil	SOI	Semiannually
Animal/Wildlife Feed	DFE/WFE	Annually
Meat-Domestic	DME	Annually
Meat-Wild	WME	Annually
Fruit	FRU	Annually

Table 3: Sample Collection Summary

Sample Type (Remarks)	Collection Type*/ Frequency**	Number of Locations	Number of Samples Collected	Number of Samples Missed
Atmospheric				
Airborne Particulates	C/W	10	519	1
Airborne Radioiodine	C/W	10	519	1
Terrestrial				
Milk (Jan.-Dec.)	G/M	1	12	0
Groundwater	G/Q***	2	7	0
Domestic Meat	G/A	2	2	0
Wild Meat	G/A	2	2	
Broadleaf Vegetation	G/M	3	9	0
Fruit	G/A	3	3	0
Soil	G/SA	10	20	0
Animal/Wildlife Feed	G/A	5	5	0
Aquatic				
Treated	Comp/WM	4	208	0
Surface Water	G/WM***	1	52	0
Untreated	G/WM***	3	156	0
Surface Water	Comp/WM	3	156	0
	G/M	5	35	0
Fish (3 species)	G/A	2	6	0
Shoreline Sediments	G/SA	4	8	0
Direct Radiation				
Thermoluminescent	C/Q***	89	339	3
Dosimeters (TLD)	C/A***	89	82	7

* Type of Collection: C = Continuous; G = Grab; Comp = Composite
** Frequency of Collection: WM = Weekly composite Monthly; W = Weekly
*** Includes quality control location, SWU and SWT QC included in weekly grab sample/composited monthly
****Hazardous weather conditions prevented sample collection
SM = Semimonthly; M = Monthly; Q = Quarterly; SA = Semiannually; A = Annually

Sample Analysis

When environmental samples are analyzed, several types of measurements may be performed to provide information about the radionuclides present. The major analyses that are performed on environmental samples collected for the Davis-Besse REMP include:

Gross beta analysis measures the total amount of beta emitting radioactive material present in a sample. Beta radiation may be released by many different radionuclides. Since beta decay gives a continuous energy spectrum rather than the discrete lines or "peaks" associated with gamma radiation, identification of specific beta emitting nuclides is much more difficult. Therefore, gross beta analysis only indicates whether the sample contains normal or abnormal concentrations of beta emitting radionuclides; it does not identify specific radionuclides. Gross beta analysis merely acts as a tool to identify samples that may require further analysis.

Gamma spectral analysis provides more specific information than does gross beta analysis. Gamma spectral analysis identifies each gamma emitting radionuclide present in the sample, and the amount of each nuclide present. Each radionuclide has a very specific "fingerprint" that allows for swift and accurate identification. For example, gamma spectral analysis can be used to identify the presence and amount of iodine-131 in a sample. Iodine-131 is a man-made radioactive isotope of iodine that may be present in the environment as a result of fallout from nuclear weapons testing, routine medical uses in diagnostic tests, and routine releases from nuclear power stations.

Tritium analysis indicates whether a sample contains the radionuclide tritium (H-3) and the amount present. As discussed in the Introduction Section, tritium is an isotope of hydrogen that emits low energy beta particles.

Strontium analysis identifies the presence and amount of strontium-89 and strontium-90 in a sample. These man-made radionuclides are found in the environment as a result of fallout from nuclear weapons testing. Strontium is usually incorporated into the calcium pool of the biosphere. In other words, strontium tends to replace calcium in living organisms and becomes incorporated in bone tissue. The principal strontium exposure pathway is via milk produced by cattle grazed on pastures exposed to deposition from airborne releases.

Gamma Doses measured by thermoluminescent dosimeters while in the field are determined by a special laboratory procedure. Table 4 provides a list of the analyses performed on environmental samples collected for the Davis-Besse REMP.

Often samples will contain little radioactivity, and may be below the lower limit of detection for the particular type of analysis used. The lower limit of detection (LLD) is the smallest amount of sample activity that can be detected with a reasonable degree of confidence, at a predetermined level. When a measurement of radioactivity is reported as less than LLD (<LLD), it means that the radioactivity is so low that it cannot be accurately measured with any degree of confidence by that particular method for an individual analysis.

Table 4: Radiochemical Analyses Performed on REMP Samples

Sample Type	Analyses Performed
Atmospheric Monitoring	
Airborne Particulate	Gross Beta Gamma Spectral Strontium-89 Strontium-90
Airborne Radioiodine	Iodine-131
Terrestrial Monitoring	
Milk	Gamma Spectral Iodine-131 Strontium-89 Strontium-90 Stable Calcium Stable Potassium
Groundwater	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90
Broadleaf Vegetation and Fruits	Gamma Spectral Iodine-131 Strontium-89 Strontium-90
Animal/Wildlife Feed	Gamma Spectral
Soil	Gamma Spectral
Wild and Domestic Meat	Gamma Spectral

Table 4: Radiochemical Analyses Performed on REMP Samples (continued)

Sample Type	Analyses Performed
Aquatic monitoring	
Untreated Surface Water	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90
Treated Surface Water	Gross Beta Gamma Spectral Tritium Strontium-89 Strontium-90 Iodine-131
Fish	Gross Beta Gamma Spectral
Shoreline Sediment	Gamma Spectral
Direct Radiation Monitoring	
Thermoluminescent Dosimeters	Gamma Dose

Sample History Comparison

The measurement of radioactive materials present in the environment will depend on factors such as weather or variations in sample collection techniques or sample analysis. This is one reason why the results of sample analyses are compared with results from other locations and from earlier years. Generally, the results of sample analyses are compared with preoperational and operational data. Additionally, the results of indicator and control locations are also compared. This allows REMP personnel to track and trend the radionuclides present in the environment, to assess whether a buildup of radionuclides is occurring and to determine the effects, if any, the operation of Davis-Besse is having on the environment. If any unusual activity is detected, it is investigated to determine whether it is attributable to the operation of Davis-Besse, or to some other source such as nuclear weapons testing.

Atmospheric Monitoring

- **Airborne Particulates:** No radioactive particulates have been detected as a result of Davis-Besse's operation. Only natural and fallout radioactivity from nuclear weapons testing and the 1986 nuclear accident at Chernobyl have been detected.
- **Airborne Radioiodine:** Radioactive iodine-131 fallout was detected in 1976, 1977, and 1978 from nuclear weapons testing, and in 1986 (0.12 to 1.2 picocuries per cubic meter) from the nuclear accident at Chernobyl.

Terrestrial Monitoring:

- **Groundwater:** Tritium was detected at indicator site T-225 at 416 pCi/L in October, and could be attributable to the operation of the Davis-Besse plant. This beach well is not used for drinking water purposes.
- **Milk:** Iodine-131 from nuclear weapons testing fallout was detected in 1976 and 1977 at concentrations of 1.36 and 23.9 picocuries/liter respectively. In 1986, concentrations of 8.5 picocuries/liter were detected from the nuclear accident at Chernobyl. No iodine-131 detected has been attributable to the operation of Davis-Besse.
- **Domestic and Wild Meat:** Only naturally occurring potassium-40 and very low cesium-137 from fallout activity has been detected in meat samples. Potassium-40 has ranged from 1.1 to 4.6 picocuries/gram weight (wet). Cesium-137 was detected in 1974, 1975, and 1981 due to fallout from nuclear weapons testing.
- **Broadleaf Vegetation and Fruits:** Only naturally occurring radioactive material and material from nuclear weapons testing have been detected.
- **Soil:** Only natural background and material from nuclear weapons testing and the 1986 nuclear accident at Chernobyl have been detected.
- **Animal/Wildlife Feed:** Only natural background and material from weapons testing have been detected.

Aquatic Monitoring

- **Surface Water (Treated and Untreated):** Historically, tritium has been detected sporadically at low levels in treated and untreated surface water at both control and indicator locations. In 2001, it was detected once above the detection limit of 330 pCi/L at T-22 Treated Surface Water indicator site at a concentration of 593 pCi/L, and twice at Indicator site T-3 for Untreated Surface Water (439 and 986 pCi/L). This could be from the operation of Davis-Besse, however, it is only a fraction of the allowable effluent concentration limit of 20,000 pCi/L in an unrestricted area, as stated in 40CFR141.
- **Fish:** Only natural background radioactive material and material from nuclear testing have been detected.

- **Shoreline Sediments:** Only natural background, material from nuclear testing and from the 1986 nuclear accident at Chernobyl have been detected.

Direct Radiation Monitoring

- **Thermoluminescent Dosimeters (TLDs):** The annual average gamma dose rates for the current reporting period recorded by TLDs have ranged from 38.4 to 78.8 millirem per year at control locations and between 25.6 and 96.4 millirem per year at indicator locations. No increase above natural background radiation attributable to the operation of Davis-Besse has been observed.

2001 Program Anomalies

Provided below is a description of 2001 environmental sample collection irregularities:

Broadleaf vegetation was only collected during the months of July through September because of seasonal availability.

On 1/11/01, the quarterly TLD at sample site T-207 was missing. This is a non-required enhancement sample and it was replaced with a new TLD.

On 3/15/01, the tygon tubing on the T-22 automatic water sampler failed. The sample size was sufficient, but smaller than usual. New tubing was installed on the sampler.

On 4/17/01, the air sampler at T-8 was found stopped due to a blown fuse. A power outage on 4/12/01 likely caused the failure. The pump restarted after fuse replacement, and the sample size was sufficient for analysis. Enhancement air sampler T-4 also appears to have been affected by the power interruption on 4/12/01, since its run time was about 3.5 hours short of the actual time of 167.7 hours.

During replacement of second quarter TLDs, quarterly and annual TLDs at sample point T-114 and co-located QC sample T-124 were missing. Third quarter TLDs for these two non-required enhancement samples were installed.

On 8/7/01, ODCM-required air sampler T-7 was found inoperable. The cause of the problem was a fault in the underground electrical supply line, which was replaced the following day. All other air samplers were evaluated for the same potential problem. Plans are in place to rewire five other samplers in 2002 as preventative maintenance.

During August, several utility poles containing Emergency Preparedness sirens were replaced. Two poles had TLD cages with annual and quarterly TLDs in them (eight in total), which were lost. The quarterly TLDs were replaced. All of the TLDs were non-required enhancements.

A power interruption at air sampler T-4 caused a difference of greater than 1% between measured and elapsed time during the week of 9/17/01.

During planned maintenance on an underground electrical supply cable on 10/30/01, three air samplers were being temporarily supplied by portable generators. Upon restoration of the normal electrical supply, the sampler at T-3 failed to restart and was replaced. The other two samplers restarted satisfactorily, but the timer on at T-1 did not advance after restart. The actual elapsed time was used with this sample, and the sampler was replaced during the next sampling period.

On 11/27/01, the T-1 air sampler was found inoperable due to a blown fuse. A power interruption was the suspected cause of failure. The run time was sufficient to obtain a valid sample, and the pump operated correctly after fuse replacement.

A power outage at sampler T-4 during the week of 11/26/01 may have caused the timer on this sampling pump to stick. The pump was replaced with a spare, as was the questionable timer.

On 12/26/01, an obstruction in the sample tubing on untreated water sampler T-22 prevented the collection of a weekly composite. The recent low lake level caused an increase of solids in the Carroll Township wet well resulted in the obstruction. The sample tubing was relocated further from the bottom in order to keep it in an area of cleaner water. A grab sample was collected, which satisfied sampling requirements.

Atmospheric Monitoring

Air Samples

Environmental air sampling is conducted to detect any increase in the concentration of airborne radionuclides that may be inhaled by humans or serve as an external radiation source. Inhaled radionuclides may be absorbed from the lungs, gastrointestinal tract, or from the skin. Air samples collected by the Davis-Besse REMP include both **airborne particulate** and **airborne radioiodine.**

Samples are collected weekly with low volume vacuum pumps, which draw a continuous sample through a glass fiber filter and charcoal cartridge at a rate of approximately one cubic foot per minute. Airborne particulate samples are collected on 47mm diameter filters. Charcoal cartridges are installed downstream of the particulate filters to sample for the airborne radioiodine.

The airborne samples are sent to an offsite contract laboratory for analysis. At the laboratory, the airborne particulate filters are stored for 72 hours before they are analyzed to allow for the decay of naturally occurring short-lived radionuclides. However, due to the short half-life of iodine-131 (approximately eight days), the airborne radioiodine cartridges are analyzed upon receipt by the contract laboratory.

Airborne Particulate

Davis-Besse continuously samples air for airborne radionuclides at ten locations. There are six indicator locations including four around the site boundary (T-1, T-2, T-3, and T-4), one at Sand Beach (T-7), and another at a local farm (T-8). There are four control locations, Oak Harbor (T-9), Port Clinton (T-11), Toledo (T-12) and Crane Creek (T-27). Gross beta analysis is performed on each of the weekly samples. Each quarter, the filters from each location are combined (composite) and analyzed for gamma emitting radionuclides, strontium-89 and strontium-90 beta-emitting radionuclides were detected at the indicator and control locations at average concentration of 0.025 pCi/m^3 and 0.025 pCi/m^3, respectively. Beryllium-7 was the only gamma emitting radionuclide detected by the gamma spectroscopic analysis of the quarterly composites.

Beryllium-7 is a naturally occurring radionuclide produced in the upper atmosphere by cosmic radiation. No other gamma emitting radionuclides were detected above their respective LLDs. Strontium-89 (Sr-89) and Strontium-90 (Sr-90) were not detected above their LLDs. These results show no adverse change in radioactivity in air samples attibutable to the operation of the Davis-Besse Nuclear Power Station in 2001.

Airborne Iodine-131

Airborne iodine-131 samples are collected at the same ten locations as the airborne particulate samples. Charcoal cartridges are placed downstream of the particulate filters. These cartridges are collected weekly, sealed in separate collection bags and sent to the laboratory for gamma analysis. There was no detectable iodine-131 above the LLD of 0.07 pCi/m^3.

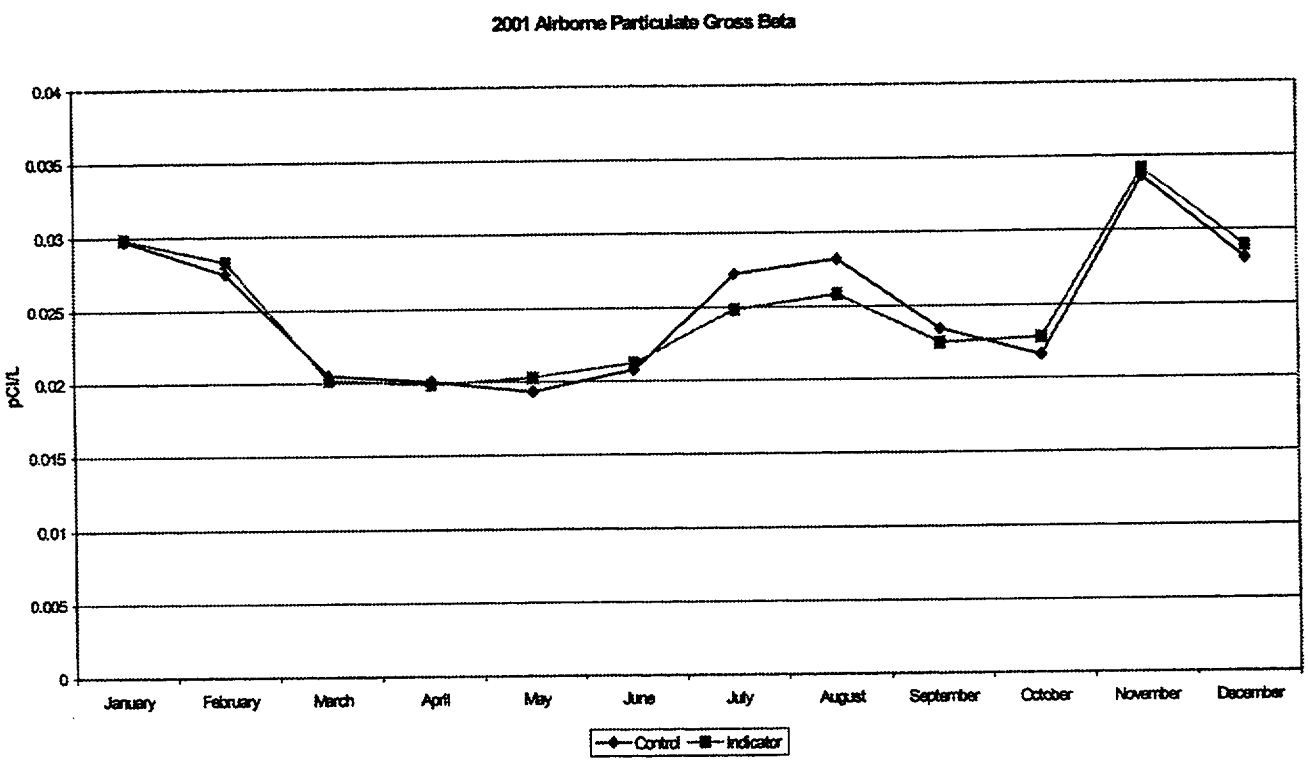


Figure 10: Concentrations of beta-emitting radionuclides in airborne particulate samples were nearly identical at indicator and control locations.

Table 5: Air Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 miles ENE of Station
T-2	I	Site boundary, 0.9 miles E of Station
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 miles S of Station
T-7	I	Sand Beach, main entrance, 0.9 miles NW of Station
T-8	I	Earl Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station

I = Indicator C = Control

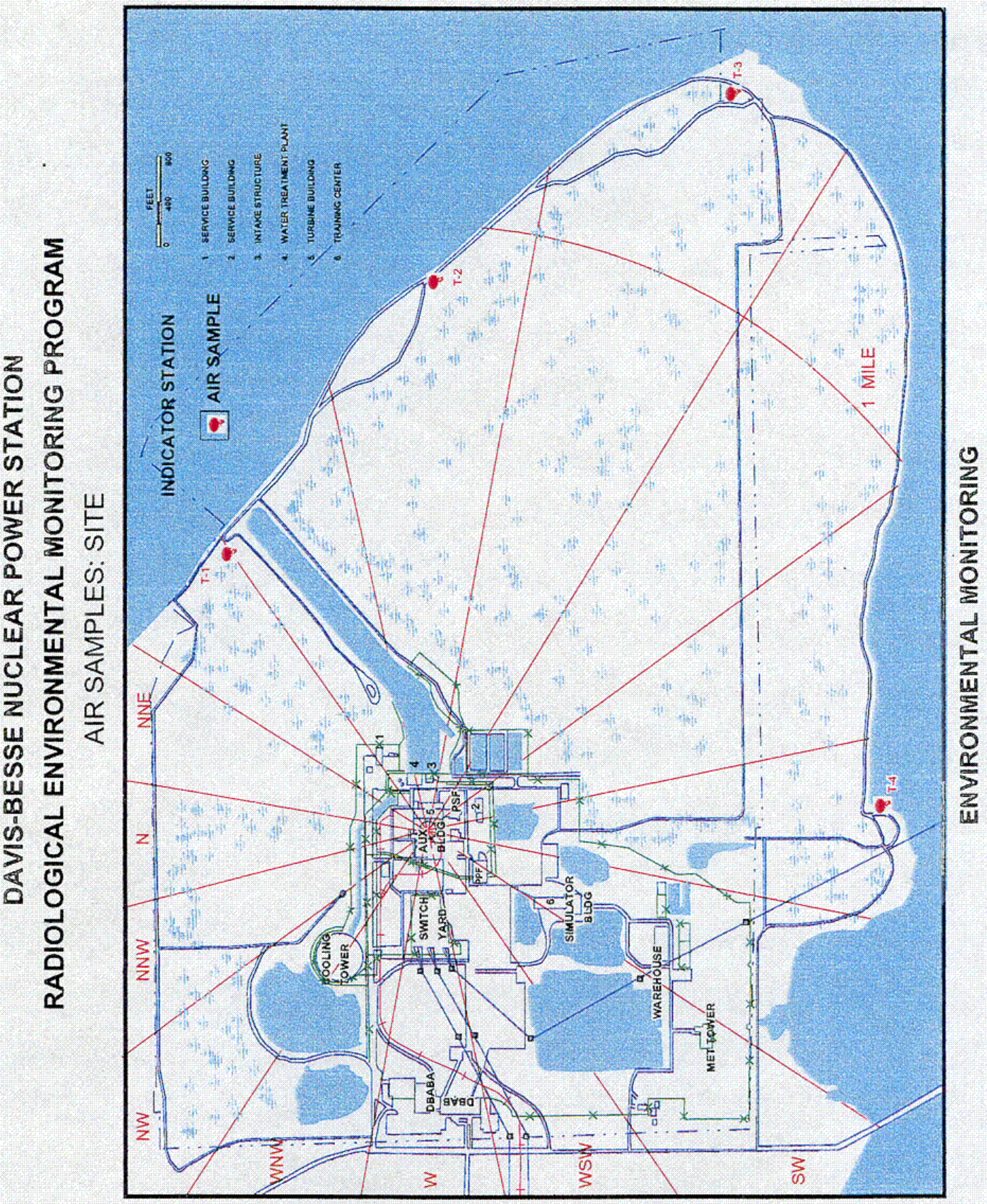


Figure 11: Air Sample Site Map

C03

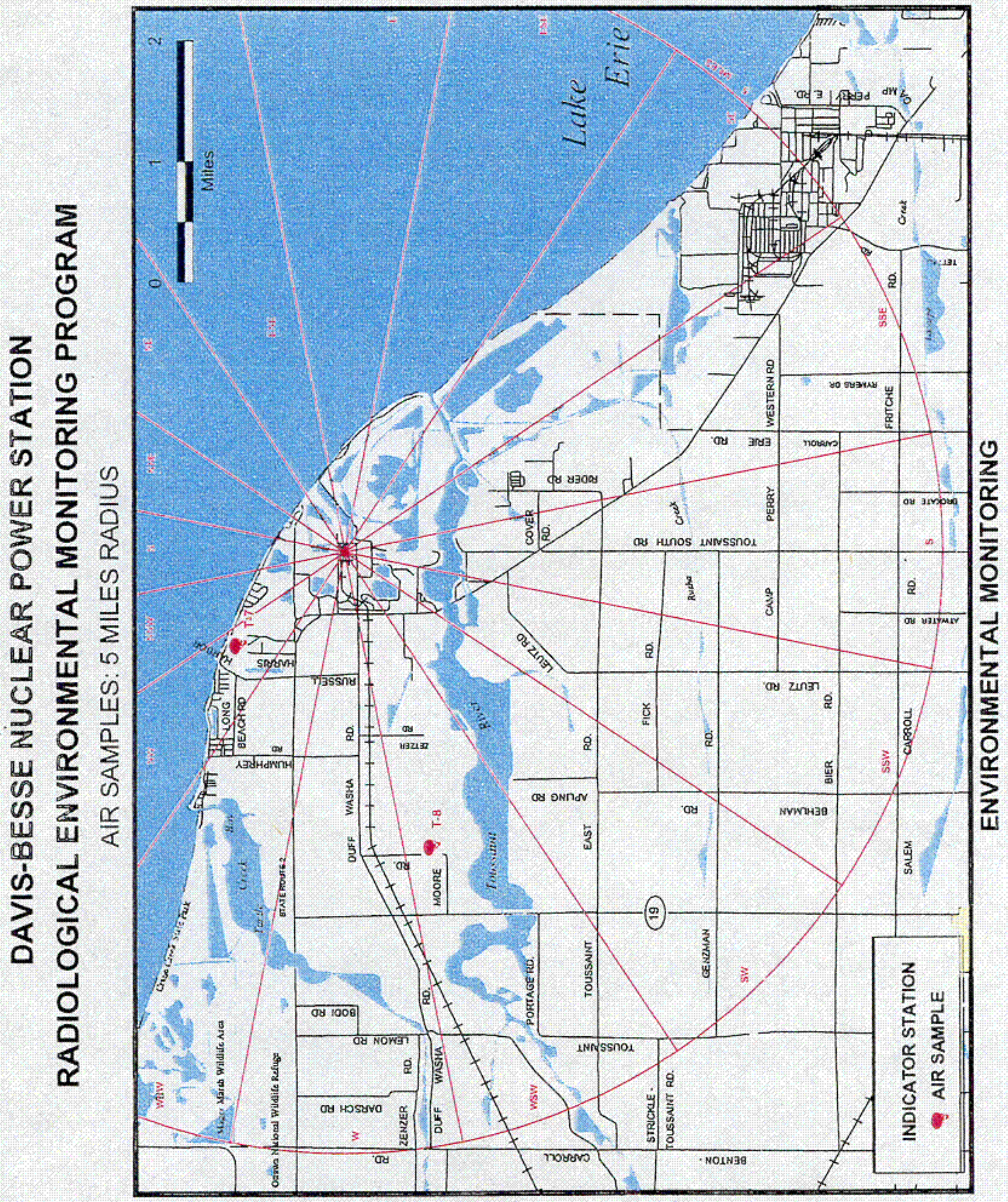


Figure 12: Air Sample 5-mile Map

C04

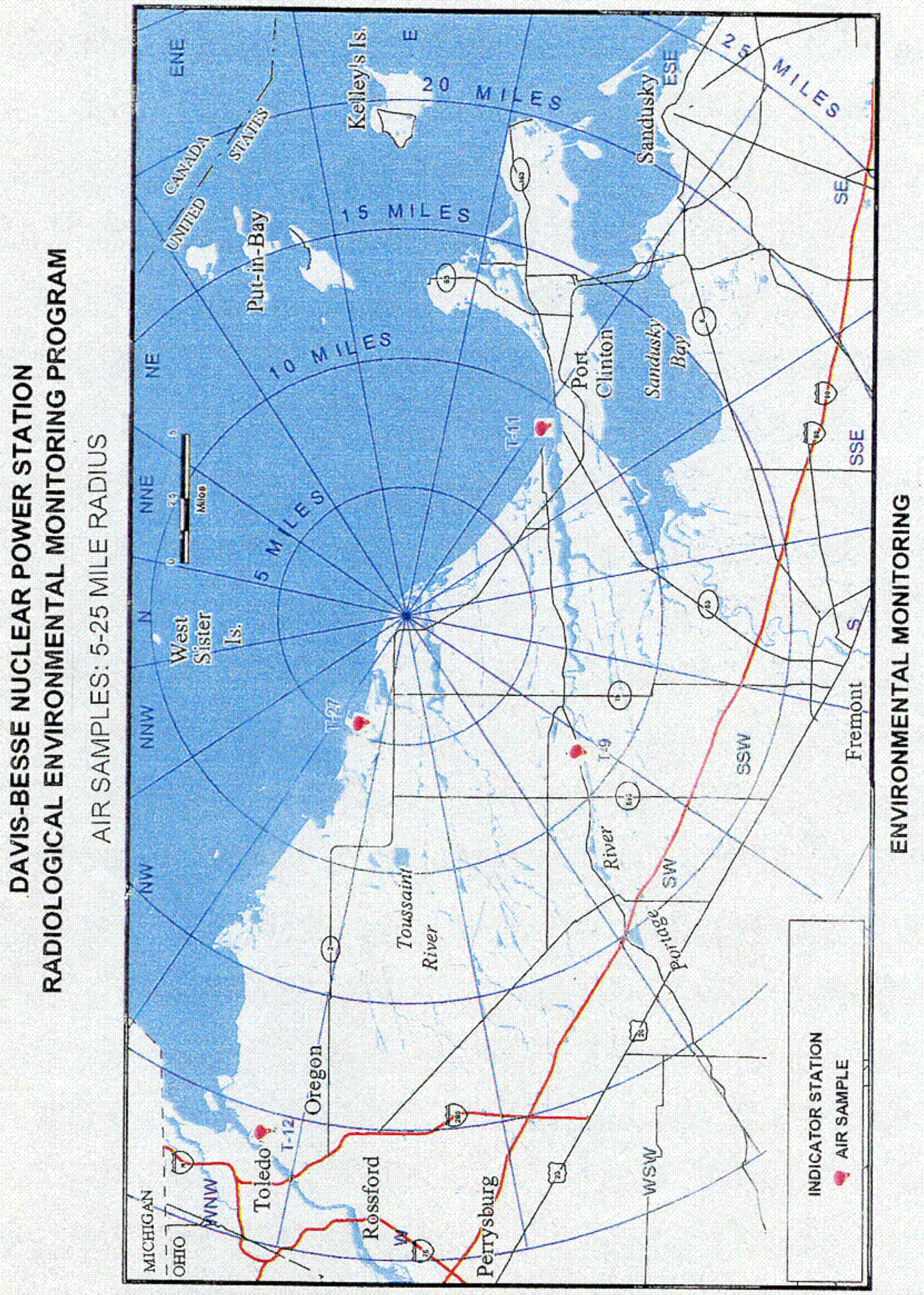


Figure 13: Air Sample 25-mile Map

C05

Terrestrial Monitoring

The collection and analysis of groundwater, milk, meat, fruits and broad leaf vegetation provides data to assess the buildup of radionuclides that may be ingested by humans. Animal and wildlife feed samples provide additional information on radionuclides that may be present in the food chain. The data from soil sampling provides information on the deposition of radionuclides from the atmosphere.

Many radionuclides are present in the environment due to sources such as cosmic radiation and fallout from nuclear weapons testing. Some of the radionuclides present are:

- **tritium**, present as a result of the interaction of cosmic radiation with the upper atmosphere and as a result of routine release from nuclear facilities
- **Beryllium-7**, present as a result of the interaction of cosmic radiation with the upper atmosphere
- **Cesium-137**, a manmade radionuclide which has been deposited in the environment, (for example, in surface soils) as a result of fallout from nuclear weapons testing and routine releases from nuclear facilities
- **Potassium-40**, a naturally occurring radionuclide normally found throughout the environment (including in the human body)
- **fallout radionuclides** from nuclear weapons testing, including strontium-89, strontium-90, cesium-137, cerium-141, cerium-144, and ruthenium-106. These radionuclides may also be released in minute amounts from nuclear facilities

The radionuclides listed above are expected to be present in many of the environmental samples collected in the vicinity of the Davis-Besse Station. The contribution of radionuclides from the operation of Davis-Besse is assessed by comparing sample results with preoperational data, operational data from previous years, control location data, and the types and amounts of radioactivity normally released from the Station in liquid and gaseous effluents.

Milk Samples

Milk sampling is a valuable tool in environmental surveillance because it provides a direct basis for assessing the build up of radionuclides in the environment that may be ingested by humans. Milk is collected and analyzed because it is one of the few foods commonly consumed soon after production. The milk pathway involves the deposition of radionuclides from atmospheric releases onto forage consumed by cows. The radionuclides present in the forage-eating cow become incorporated into the milk, which is then consumed by humans.

When available, milk samples are collected at indicator and control locations once a month from November through April, and twice a month between May and October. Sampling is increased in the summer when the herds are usually outside on pasture and not on stored feed. In December of 1993, indicator location T-8 was eliminated from the sampling program, and no other indicator milk site has existed since that time. The control location will continue to be sampled monthly in order to gather additional baseline data. If any dairy animals are discovered within five miles of the station, efforts will be made to include them in the milk-sampling program as indicator sites.

The 2001 milk samples were analyzed for strontium-89, strontium-90, iodine-131 and other gamma emitting radionuclides, stable calcium and potassium. A total of 12 milk samples were collected in 2001. Strontium-89 was not detected above its LLD. Strontium-90 was detected in all but one sample collected. The annual average concentration of strontium-90 was 1.00 pCi/l. For all sample sites, the annual average concentration was similar to those measured in the previous years.

Iodine-131 was not detected in any of the milk samples above the LLD of 0.40 pCi/l. The concentrations of barium-140 and cesium-137 were below their respective LLDs in all samples collected.

Since the chemistries of calcium and strontium are similar, as are potassium and cesium, organisms tend to deposit cesium radioisotopes in muscle tissue and strontium radioisotopes in bones. In order to detect the potential environmental accumulation of these radionuclides, the ratios of the strontium radioactivity (pCi/l) to the concentration of calcium (g/l), and the cesium radioactivity (pCi/l) compared to the concentration of potassium (g/l) were monitored in milk. These ratios are compared to standard values to determine if buildup is occurring. No statistically significant variations in the ratios were observed.

Table 6: Milk Monitoring Location

Sample Location Number	Type of Location	Location Description
T-24	C	Toft Dairy, Sandusky, 21.0 miles SE of Station

C = Control

Groundwater Samples

Soil acts as a filter and an ion exchange medium for most radionuclides. However, tritium and other radionuclides such as ruthenium-106 have a potential to seep through the soil and could reach groundwater. Davis-Besse does not discharge its liquid effluents directly to the ground. In the past, REMP personnel sampled local wells on a quarterly basis to ensure early detection of any adverse impact on the local groundwater supplies due to Station operation. In addition, a quality control sample was collected at one of the wells each quarter. The groundwater samples were analyzed for beta emitting radionuclides, tritium, strontium-89, strontium-90 and gamma emitting radionuclides.

During the fall of 1998, the Carroll Township Water Plant was placed into operation, and offered residents a reliable source of high-quality, inexpensive drinking water. This facility has replaced all of the drinking water wells within five miles of Davis-Besse, as verified by the Ottawa County Health Department. During the third quarter of 2001, a beach well was located within five miles of the Station. Although the residents confirmed that they use only the township system for their drinking water needs, they still use the well water for outside purposes. This well was added to our sampling program as an Indicator location during the fall of 2001. One Control location is still sampled quarterly at T-27, and it averaged <3.7 pCi/l gross beta for the year 2001. Strontium-90 was detected in the Control sample T-27 on one occasion, and tritium was detected above the detection limit at 416 pCi/L at the Indicator location at T-225.

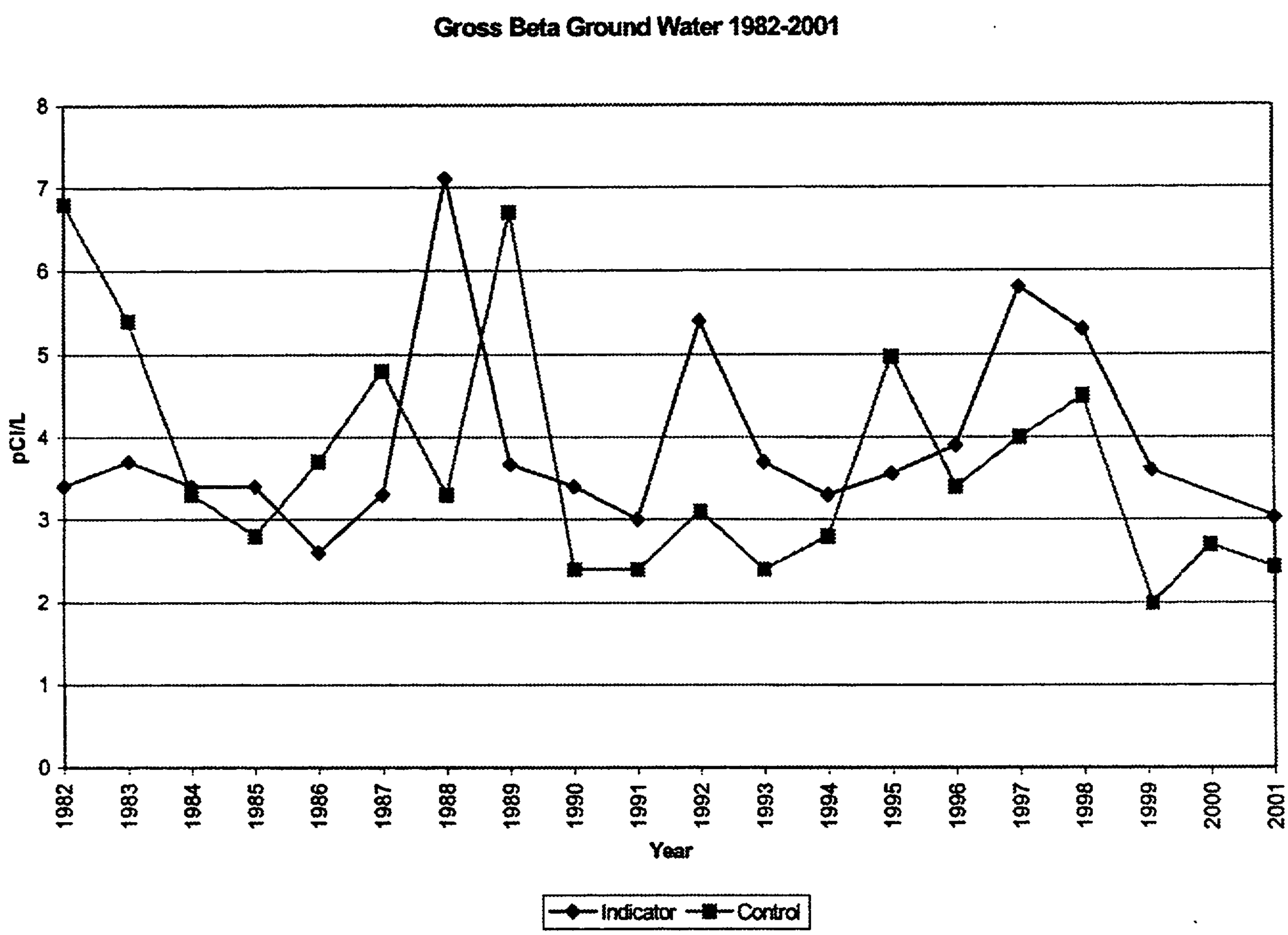


Figure 14: Shown above are the annual averages for gross beta in groundwater from 1982 - 2001.

Table 7: Groundwater Monitoring Locations

Sample Location Number	Type of Location	Location Description
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-225	I	Ben Shultz residence, 1.55 miles NW of Station

C = control
I = indicator

Broadleaf Vegetation and Fruit Samples

Fruits and broadleaf vegetation also represent a direct pathway to humans. Fruits and broadleaf vegetation may become contaminated by deposition of airborne radioactivity (nuclear weapons fallout or airborne releases from nuclear facilities) or from irrigation water drawn from lake water receiving liquid effluents (hospitals, nuclear facilities, etc.). Radionuclides from the soil may be absorbed by the roots of the plants and become incorporated into the edible portions. During the growing season, edible broadleaf vegetation samples, such as kale and cabbage, are collected from gardens and farms in the vicinity of the Station. Fruit, such as apples, is collected from orchards in the vicinity of Davis-Besse.

In 2001, broadleaf vegetation samples were collected at two indicator locations (T-17 and T-19) and one control location (T-37). Fruit samples were collected at two indicator locations (T-8 and T-25) and one control location (T-209). Broadleaf vegetation was collected once per month during the growing season and consisted of cabbage. The fruit collected was apples. All samples were analyzed for gamma emitting radionuclides, strontium-89, strontium-90, and iodine-131.

Iodine-131 was not detected above the LLD of 0.025 pCi/g (wet) in any broadleaf vegetation nor above the LLD of 0.017 pCi/g (wet) in fruit samples. The only gamma-emitting radionuclide detected in the fruit and broadleaf vegetation samples was potassium-40, which is naturally occurring. In broadleaf vegetation, strontium-90 (Sr-90) was detected at average concentrations of 0.008 pCi/g (wet) for indicator locations and below the LLD of 0.004 pCi/g (wet) for control locations. In the fruit samples, Sr-90 was not detected above 0.001 pCi/g (wet) at indicator sites T-8 and T-25, and was detected at 0.001 pCi/g(wet) at control site T-209. Results of broadleaf vegetation and fruit samples were similar to results observed in previous years. The operation of Davis-Besse had no observable adverse radiological effect on the surrounding environment in 2001.

Table 8: Broadleaf Vegetation and Fruit Locations

Sample Location Number	Type of Location	Location Description
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-17	I	J. Sobieralski, 1.8 miles SSE of Station
T-19	I	B. Skinner, 1.0 mile W of Station
T-25	I	Witt Farm, 1.6 miles south of Station
T-37	C	Bench Farm, 13.0 miles SW of Station
T-209	C	Roving Control Location

I = indicator, C = control

Animal/Wildlife Feed Samples

Vegetation consumed by wildlife, and feed consumed by domestic animals can provide an indication of airborne radionuclides deposited in the vicinity of the Station. Analyses of animal/wildlife feed samples can also provide data for determining radionuclide concentration in the food chain. Domestic animals feed samples are collected at two domestic meat-sampling locations. Wildlife feed samples are collected from the Navarre Marsh and from a local marsh within five miles of the Station. As in all terrestrial samples, naturally occurring potassium-40, cosmic ray-produced radionuclides such as beryllium-7, and fallout radionuclides from nuclear weapons testing may be present in the feed samples.

There is one indicator (T-197) and one control location (T-34). The feed collected was chicken feed. All samples were analyzed for gamma-emitting radionuclides.

Wildlife feed was collected annually at three locations (T-31, T-32 and T-198). The samples consisted of the edible portions of cattails. Samples were analyzed for gamma-emitting radionuclides.

In both the animal and wildlife feed, naturally occurring potassium-40 was detected. Beryllium-7 was detected at T-31 and T-32. All other radionuclides were below their respective LLDs. The operation of Davis-Besse had no adverse effect on the surrounding environment.

Table 9: Animal/Wildlife Feed Locations

Sample Location Number	Type of Location	Location Description
T-31	I	Davis-Besse, onsite roving location
T-32	C	Roving offsite location – collected 7.0 miles W of station in 2001
T-34	C	Brian Lowe residence, 8.2 miles W of the Station
T-197	I	Lochotzki residence 4.0 miles W of the Station Lemon Road
T-198	I	Toussaint Creek Wildlife Area 4.0 miles WSW of the Station

I = indicator C = control

Wild and Domestic Meat Samples

Sampling of domestic and wild meat provides information on environmental radionuclide concentrations that humans may be exposed to through an ingestion pathway. The principle pathways for radionuclide contamination of meat animals include deposition of airborne radioactivity in their food and drinking water and contamination of their drinking water from radionuclides released in liquid effluents.

The REMP generally collects wild meat and domestic meat (chicken) on an annual basis. Wild animals commonly consumed by residents in the vicinity of Davis-Besse include waterfowl, deer, rabbits and muskrats. Analyses from these animals provide general information on radionuclide concentration in the food chain. When evaluating the results from analyses performed on meat animals, it is important to consider the age, diet and mobility of the animal before drawing conclusions on radionuclides concentration in the local environment or in a species as a whole.

Meat samples were taken in 2001 as follows:

- Domestic Meat: Chickens were collected at one indicator location (T-197) and one control location (T-34). The samples were analyzed for gamma emitting nuclides. Only naturally-occurring radionuclides were detected in the edible portion of the chicken.
- Wild Meat: Muskrat samples were collected on Station property and showed only naturally occurring activity due to Potassium 40.

Table 10: Wild and Domestic Meat Locations

Sample Location Number	Type of Location	Location Description
T-31	I	Onsite roving location
T-34	C	Brian Lowe residence, 8.2 miles W of the the Station
T-197	I	Lochotzki residence, Lemon Road, 4.0 miles W of the Station
T-210	C	Roving offsite location (5.5 mi. WNW of the Station in 2001)

I = indicator C = control

Soil Samples

Soil samples are generally collected twice a year at the sites that are equipped with air samplers. Only the top layer of soil is sampled in an effort to identify possible trends in the local environmental nuclide concentration caused by atmospheric deposition of fallout and station-released radionuclides. Generally, the sites are relatively undisturbed, so that the sample will be representative of the actual deposition in the area. Ideally, there should be little or no vegetation present, because the vegetation could affect the results of analyses. Approximately five pounds of soil are taken from the top two inches at each site. Many naturally occurring radionuclides such as beryllium-7 (Be-7), potassium-40 (K-40) and fallout radionuclides from nuclear weapons testing are detected. Fallout radionuclides that are often detected include strontium-90 (Sr-90), cesium-137 (Cs-137), cerium-141 (Ce-141) and ruthenium-106 (Ru-106).

During 2001, soil was collected at ten sites in April and October. The indicator locations included T-1, T-2, T-3, T-4, T-7, and T-8. The control locations were T-9, T-11, T-12, and T-27. All soil samples were analyzed for gamma emitting radionuclides. The results show that the only gamma emitter detected in addition to naturally occurring Be-7 and K-40 was Cs-137. Cs-137 was found in both indicator and control locations at average concentrations of 0.13 pCi/g dry and 0.23 pCi/g dry, respectively. The concentrations were similar to that observed in previous years (Figure15).

Cs-137 in Soil 1972-2001

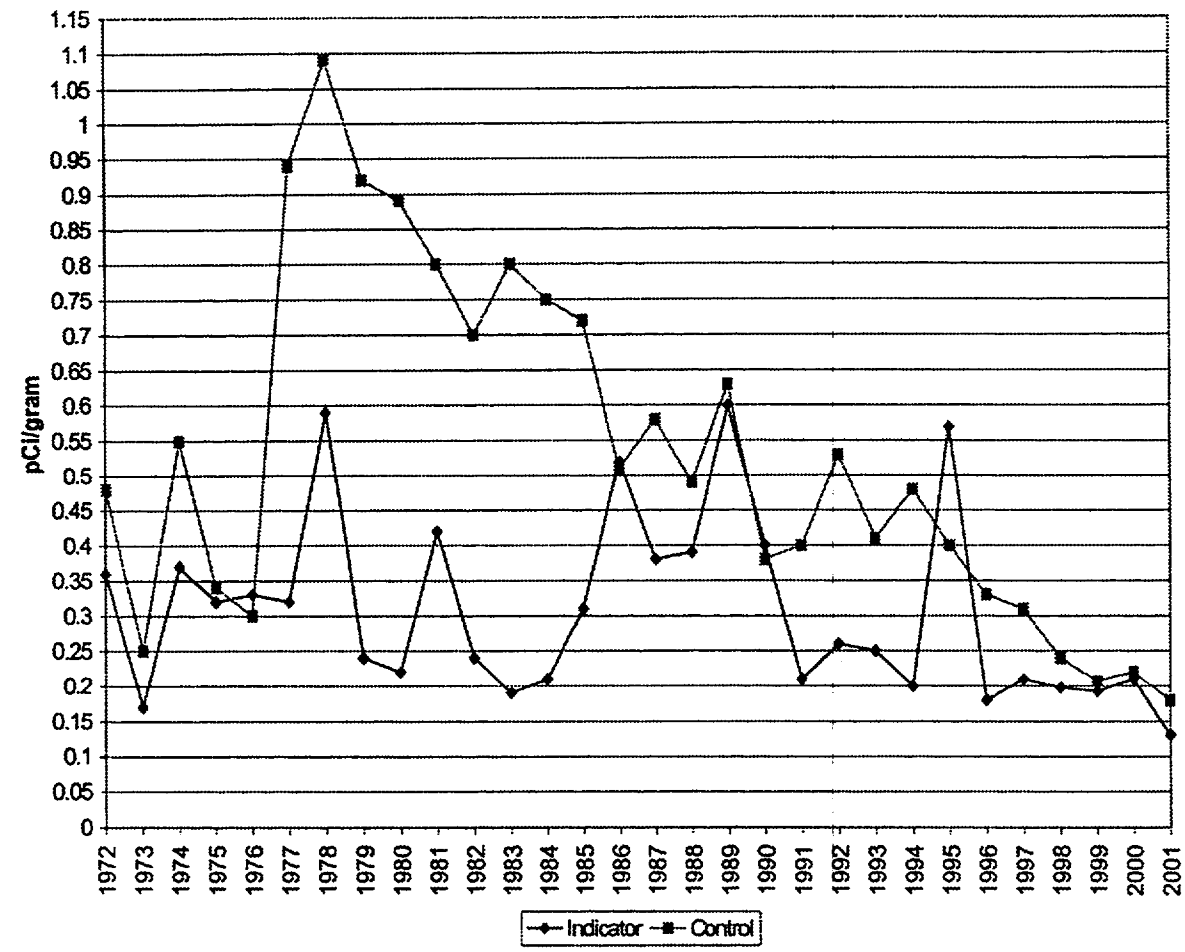


Figure 15: The concentration of cesium-137 in soil has remained fairly constant over the years REMP has been conducted. The peak seen in 1978 was due to fallout from nuclear weapons testing.

Table 11: Soil Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 miles ENE of Station
T-2	I	Site boundary, 0.9 miles E of Station
T-3	I	Site boundary 1.4 miles ESE of Station
T-4	I	Site boundary 0.8 miles S of Station
T-7	I	Sand Beach, main entrance, 0.9 miles NW of Station
T-8	I	Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station

I = indicator C = control

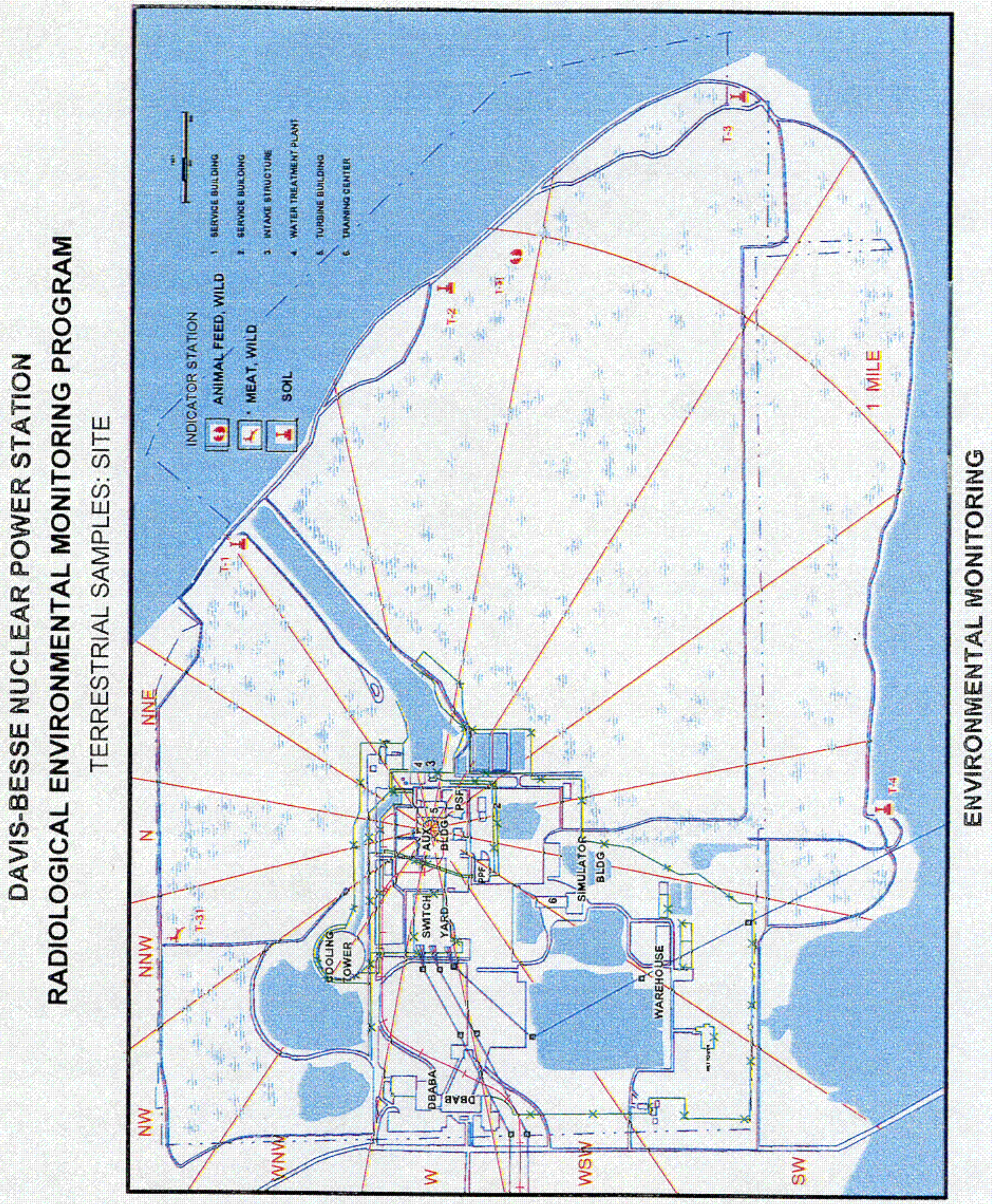


Figure 16: Terrestrial Site Map

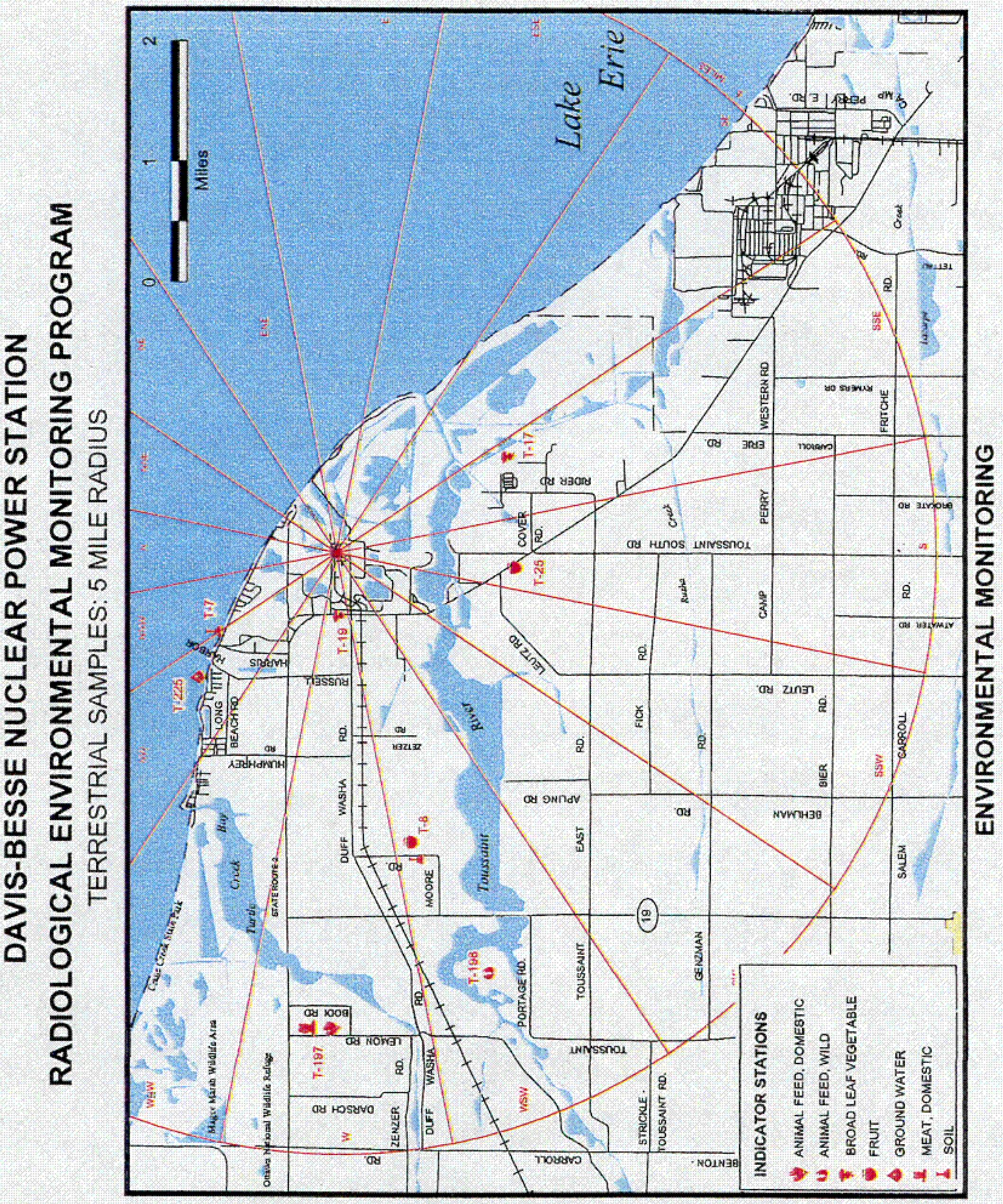


Figure 17: Terrestrial 5-mile Map

C07

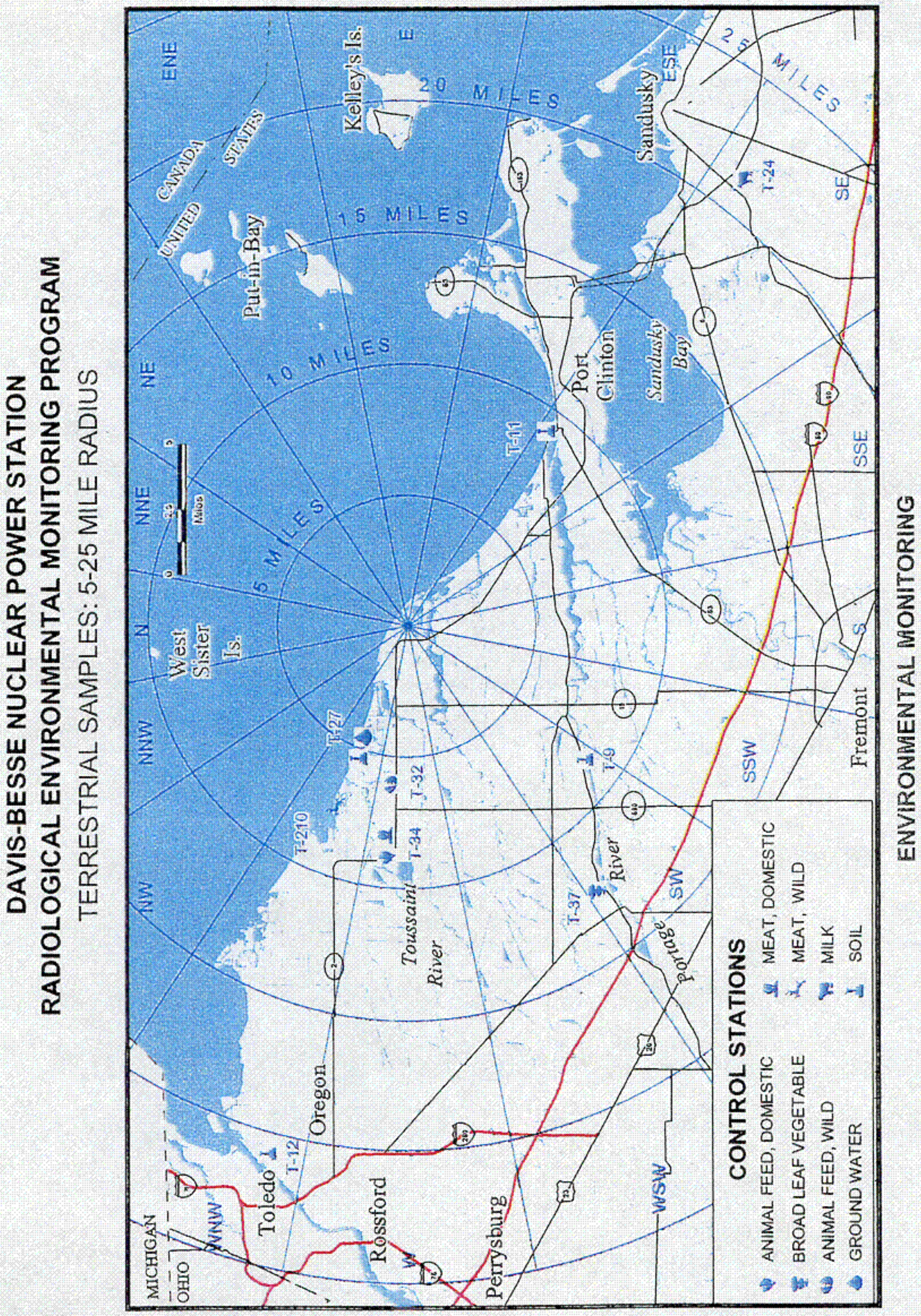


Figure 18: Terrestrial 25-mile Map

C08

Aquatic Monitoring

Radionuclides may be present in Lake Erie from many sources including atmospheric deposition, run-off/soil erosion, and releases of radioactive material in liquid effluents from hospitals or nuclear facilities. These sources provide two forms of potential exposure to radiation, external and internal. External exposure can occur from the surface of the water, shoreline sediments and from immersion (swimming) in the water. Internal exposure can occur from ingestion of radionuclides, either directly from drinking water, or as a result of the transfer of radionuclides through the aquatic food chain with eventual consumption of aquatic organisms, such as fish. To monitor these pathways, Davis-Besse samples treated surface water (drinking water), untreated surface water (lake or river water), fish, and shoreline sediments.

Treated Surface Water

Treated surface water is water from Lake Erie, which has been processed for human consumption. Radiochemical analysis of this processed water provides a direct basis for assessing the dose to humans from ingestion of drinking water.

Samples of treated surface water were collected from two indicators (T-22B and T-50) and two control locations (T-11 and T-12A). These locations include the water treatment facilities for Carroll Township, Erie Industrial Park, Port Clinton and Toledo. Samples were collected weekly and composited monthly. The monthly composites were analyzed for beta emitting radionuclides. The samples were also composited in a quarterly sample and analyzed for strontium-89, strontium-90, gamma emitting radionuclides, and tritium. One QC sample was collected from a routine location, which was changed each month.

The annual average of beta-emitting radionuclides for indicator and control locations was 2.5pCi/l and 2.3 pCi/l, respectively. These results are similar to previous years as shown in Figure 19. Tritium was detected once above the LLD of 330 pCi/l during the second quarter. The concentration at indicator location T-22 was 593 pCi/l, which is well below the allowable limit of 20,000 pCi/L. Strontium-89 was not detected above the LLD of 1.3 pCi/l. Strontium-90 activity between 0.4 and 1.0 pCi/l was detected five times. These results are similar to those of previous years and indicate no adverse impact on the environment resulting from the operation of Davis-Besse in 2001.

Each month, weekly quality control samples were collected at different locations. The results of the analyses from the quality control samples were consistent with the routine samples. The average concentration of beta emitting radionuclides detected at the QC location was 2.52 pCi/l. There was good agreement between the routine and QC locations.

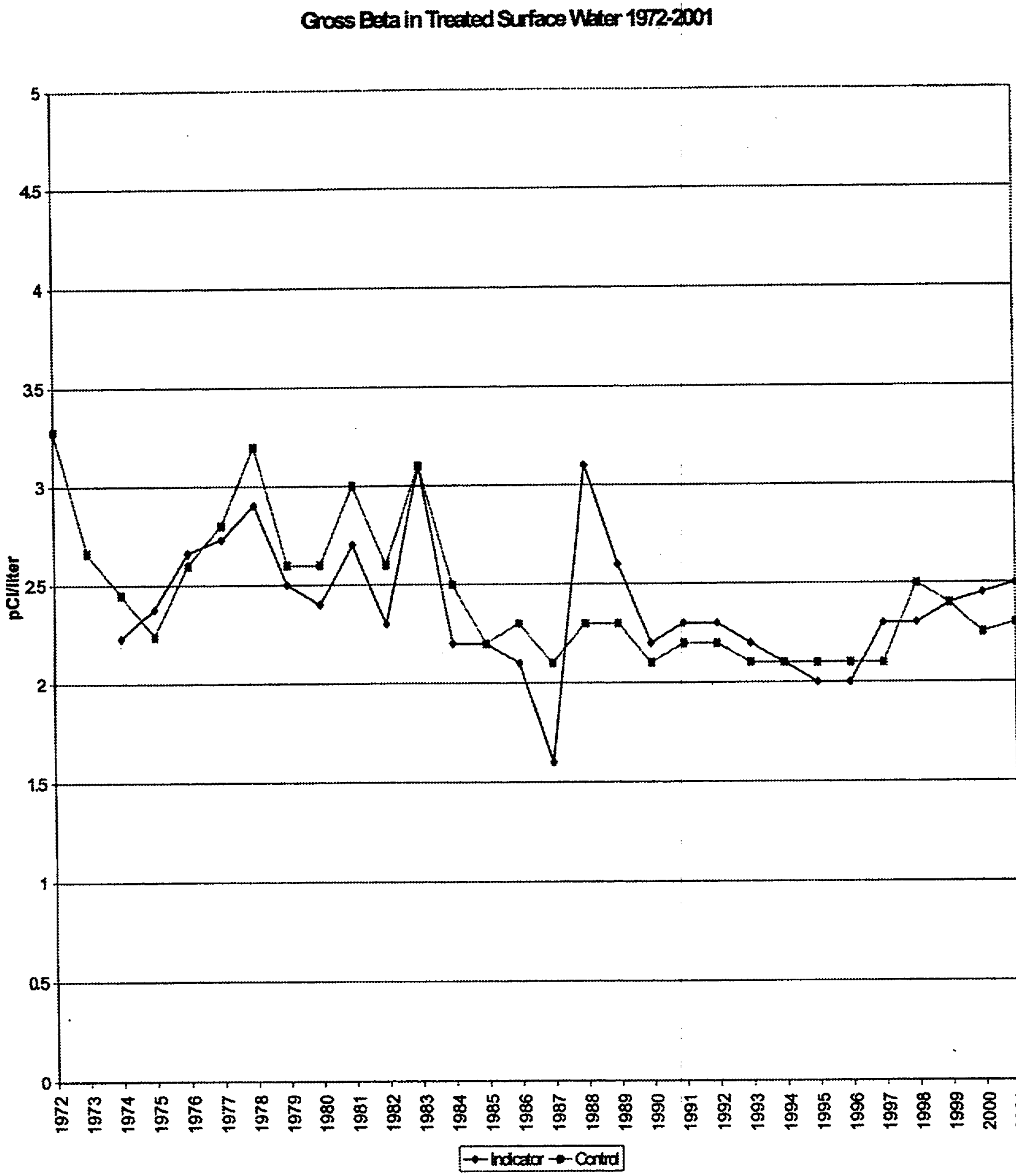


Figure 19: Since 1974, the annual concentrations of beta emitting radionuclides in treated surface water samples collected from indicator locations have been consistent with those from control locations. Davis-Besse has had no measurable radiological impact on surface water used to make drinking water.

Table 12: Treated Surface Water Locations

Sample Location Number	Type of Location	Location Description
T-11	C	Port Clinton Water Treatment Plant 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant 23.5 miles WNW of Station
T-22B	I	Carroll Township water sampled at Davis-Besse
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-143	QC	Quality Control Site

I = indicator, C = control, QC = quality control

Untreated Surface Water

Sampling and analysis of untreated surface water provides a method of assessing the dose to humans from external exposure from the lake surface as well as from immersion in the water. It also provides information on the radionuclides present, which may affect drinking water, fish, and irrigated crops.

Routine Program

The routine program is the basic sampling program that is performed year round. Untreated water samples are collected from water intakes used by nearby water treatment plants. Routine samples are collected at Port Clinton, Toledo, Carroll Township Intake and Erie Industrial Park. A sample is also collected from Lake Erie at the mouth of the Toussaint River. These samples are collected weekly and composited monthly. The monthly composite is analyzed for beta emitting radionuclides, tritium, and gamma emitting radionuclides. The samples are composited further quarterly and analyzed for strontium-89 and strontium-90. A QC sample is also collected weekly, with the location changing each month.

Summer Program

The summer program is designed to supplement the routine untreated water sampling program in order to provide a more comprehensive study during the months of high lake recreational activity, such as boating, fishing, and swimming. These samples are obtained monthly in areas along the shoreline of Lake Erie, and analyzed for beta emitting radioactivity, tritium, strontium-89, strontium-90 and gamma-emitting radionuclides.

Sample Results

For the routine untreated surface water samples composited weekly, the beta emitting radionuclides had an average concentration of 3.1 pCi/L at both indicator and control locations. The average concentration of beta-emitting radionuclides in summer lakewater samples was 3.05 pCi/L at indicator and 3.36 pCi/L at control locations.

During 2001, tritium was detected in 2 untreated surface water samples, ranging from 439 pCi/L to 986 pCi/L (well below the established 40CFR141 limit of 20,000 pCi/L). Both were at indicator locations, and could be due to the operation of the Davis-Besse Nuclear Power Station.

Cesium-137 was not detectable in samples of untreated water above the LLD of 6.4 pCi/L.

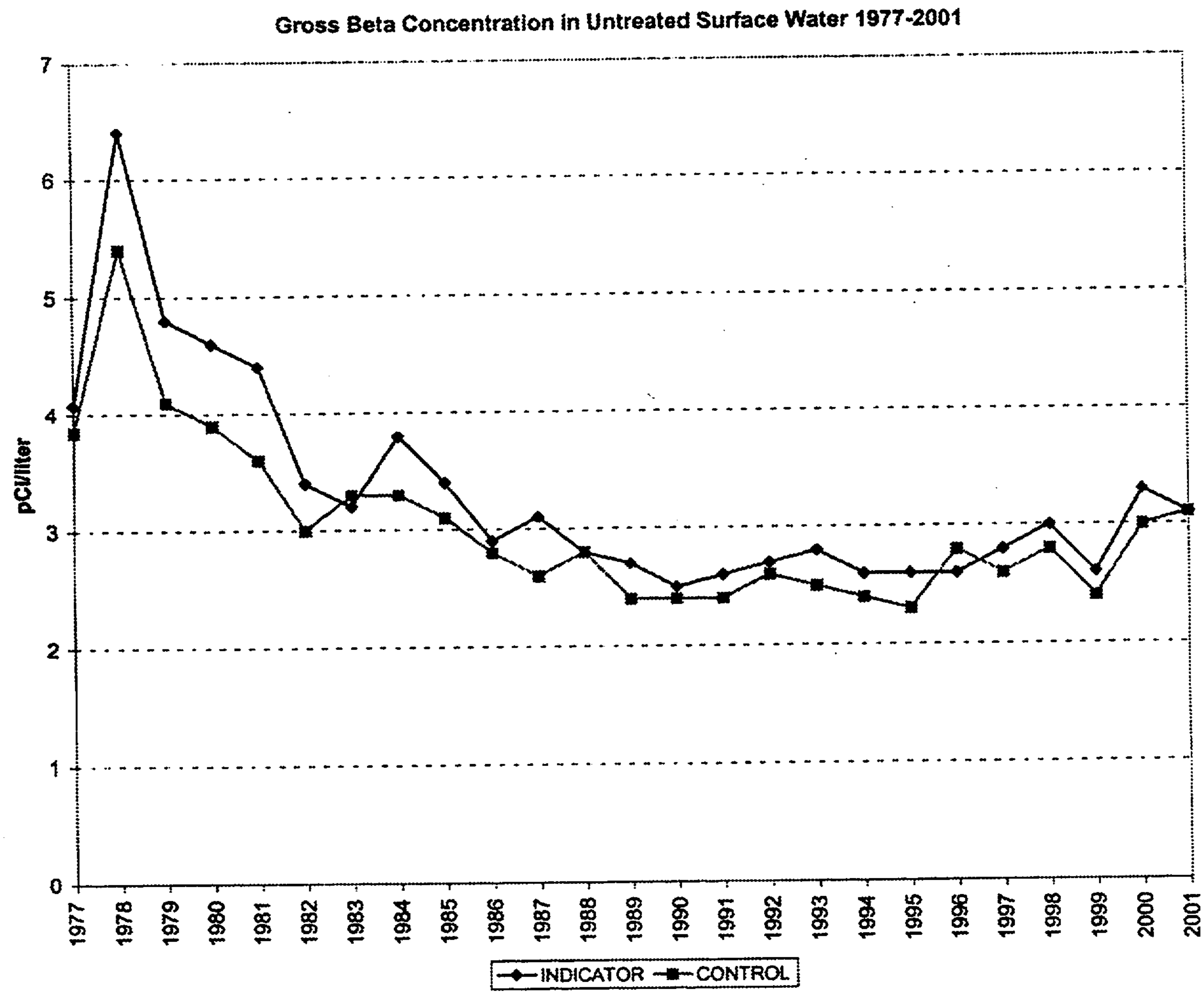


Figure 20: The average concentration of beta emitting radionuclides in untreated water was similar between control and indicator locations. This demonstrates that Davis-Besse had no significant radiological impact on the surrounding environment.

Each month, weekly quality control samples were collected at different locations. The results of the analyses from the quality control samples were consistent with the routine samples. The average concentration of beta emitting radionuclides detected at the QC location was 2.98 pCi/l and 2.99 pCi/l at routine locations.

Table 13: Untreated Surface Water Locations

Sample Location Number	Type of Location	Location Description
T-3	I	Site boundary, 1.4 miles ESE of Station
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, sample taken from intake crib, 11.25 miles NW of Station
T-22A	I	Carroll Township Water Intake, Humphrey Rd., 3.0 miles NW of Station
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-132	I	Lake Erie, 1.0 miles E of Station
T-134	I	Lake Erie, 1.4 miles NW of Station
T-137	C	Lake Erie, 5.8 miles WNW of Station
T-145	QC	Roving Quality Control Site
T-158	C	Lake Erie, 10.0 miles WNW of Station
T-162	C	Lake Erie, 5.4 miles SE of Station

I = indicator, C = control

Shoreline Sediment

The sampling of shoreline sediments can provide an indication of the accumulation of undissolved radionuclides which may lead to internal exposure to humans through the ingestion of fish, through resuspension into drinking water supplies, or as an external radiation source from shoreline exposure to fishermen and swimmers.

Samples of deposited sediments in water along the shore were collected at various times from three indicator sites (T-3, T-4, and T-132) and one control location (T-27). Shoreline sediment was collected with a shovel. All samples were analyzed for gamma emitting radionuclides. Naturally occurring potassium-40 was detected at both control and indicator locations. Cs-137 was not detected at any locations. These results are similar to previous years.

Table 14: Shoreline Sediment Locations

Sample Location Number	Type of Location	Location Description
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 miles S of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-132	I	Lake Erie, 1.0 miles E of Station

I = indicator C = control

Fish Sample

Fish are analyzed primarily to quantify the dietary radionuclide intake by humans, and secondarily to serve as indicators of radioactivity in the aquatic ecosystem. The principal nuclides which may be detected in fish include naturally occurring potassium-40, as well as cesium-137, and strontium-90. Depending upon the feeding habit of the species (e.g., bottom-feeder versus predator), results from sample analyses may vary.

With the aid of a local commercial fisherman, Davis-Besse routinely collects three species of fish once per year from sampling locations near the Station's liquid discharge point and more than ten miles away from the Station where fish populations would not be expected to be impacted by the Station operation. Walleye are collected because they are a popular sport fish and white perch or white bass are collected because they are an important commercial fish. Carp are collected because they are bottom feeders where contaminants may settle.

The average concentration of beta emitting radionuclides in fish was similar for indicator and control locations (2.97 pCi/g and 2.82 pCi/g wet weight, respectively). Cesium-137 was not detected above the LLD of <0.020 pCi/g for indicator and control locations. No other gamma emitters were detected above their respective LLDs.

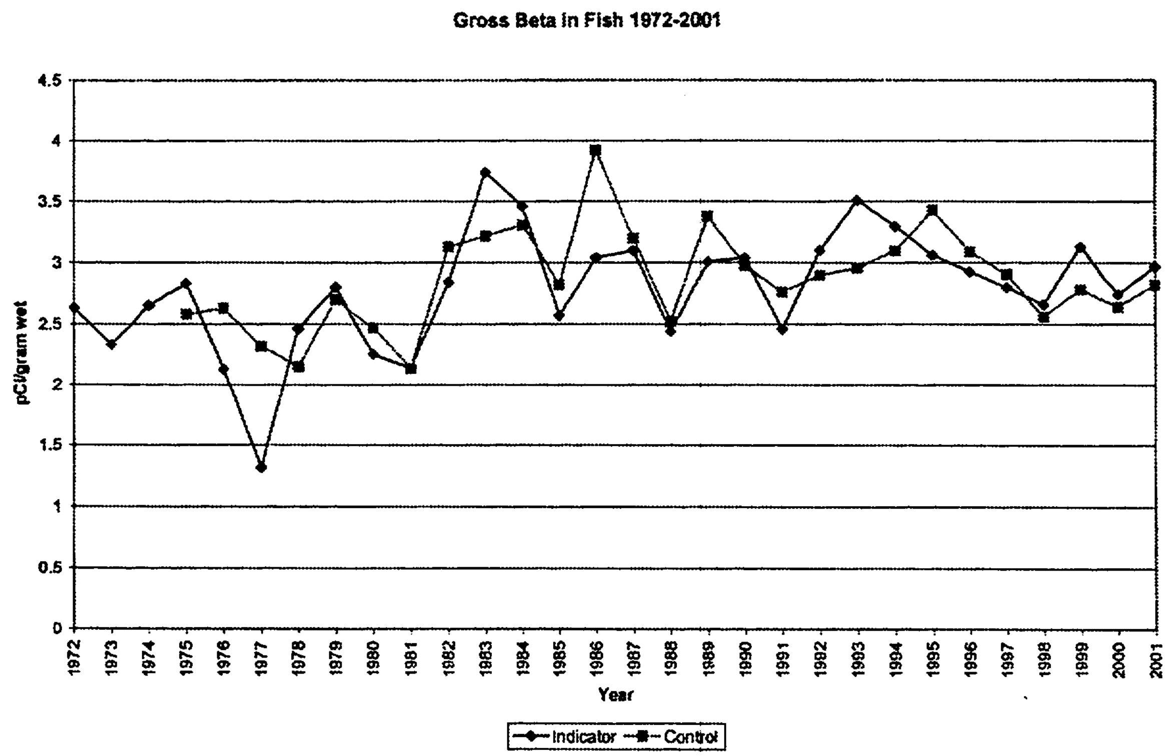


Figure 21: Average concentrations of beta emitting radionuclides in fish samples were similar at indicator and control locations and were within the range of results of previous years.

Table 15: Fish Locations

Sample Location Number	Type of Location	Location Description
T-33	I	Lake Erie, within 5 miles radius of Station
T-35	C	Lake Erie, greater than 10 mile radius of Station

I = indicator C= control

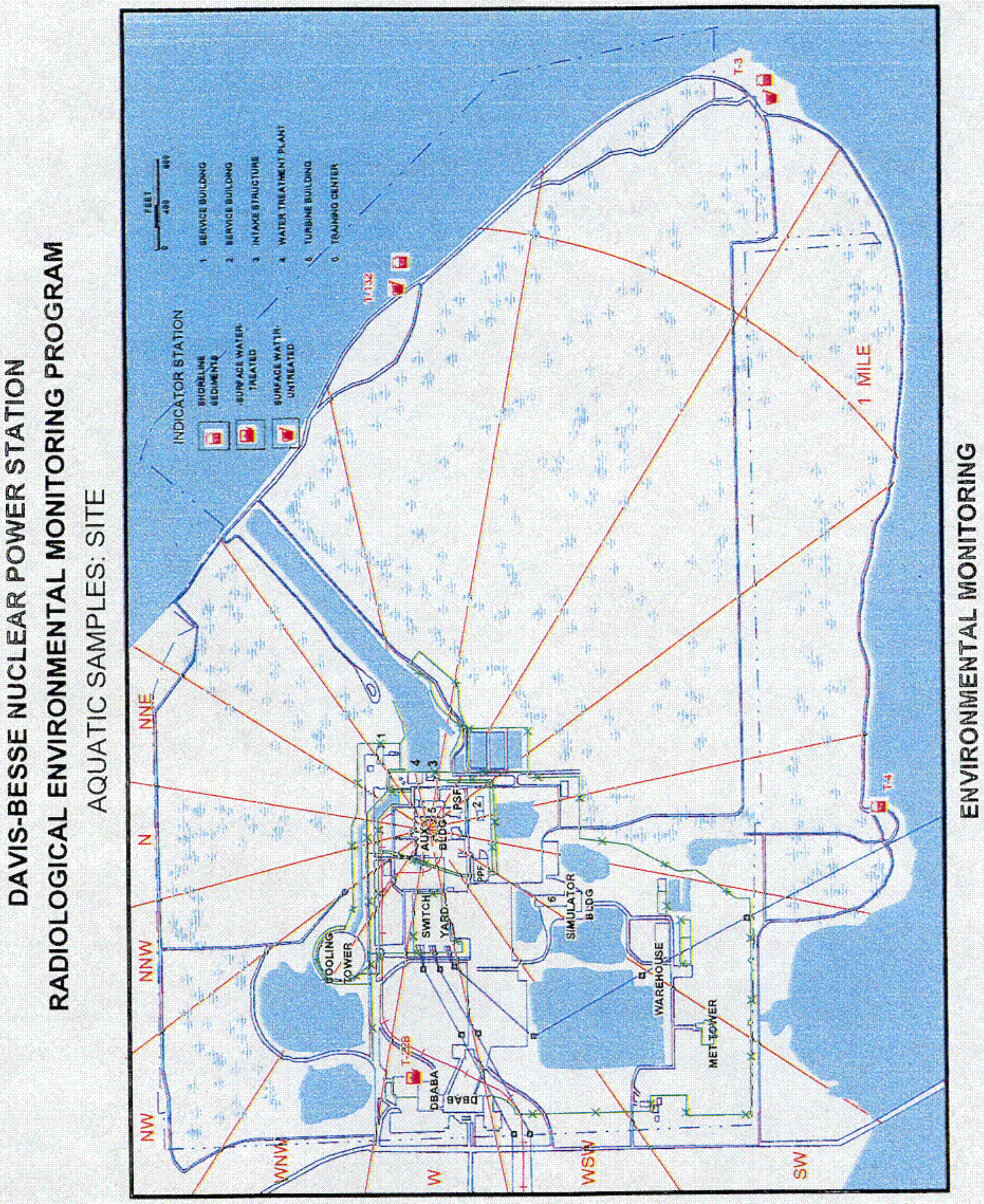


Figure 22: Aquatic Site Map

C09

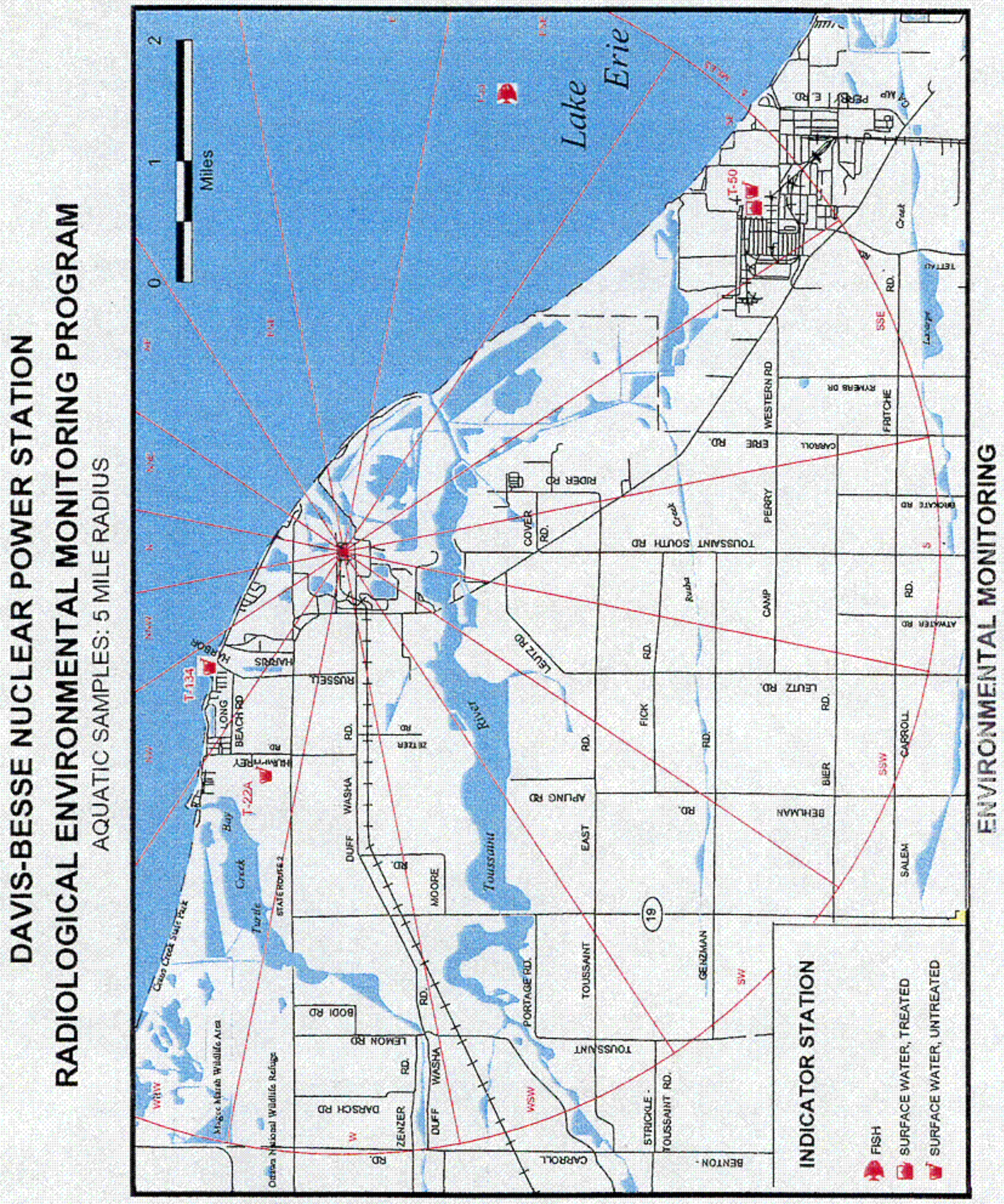
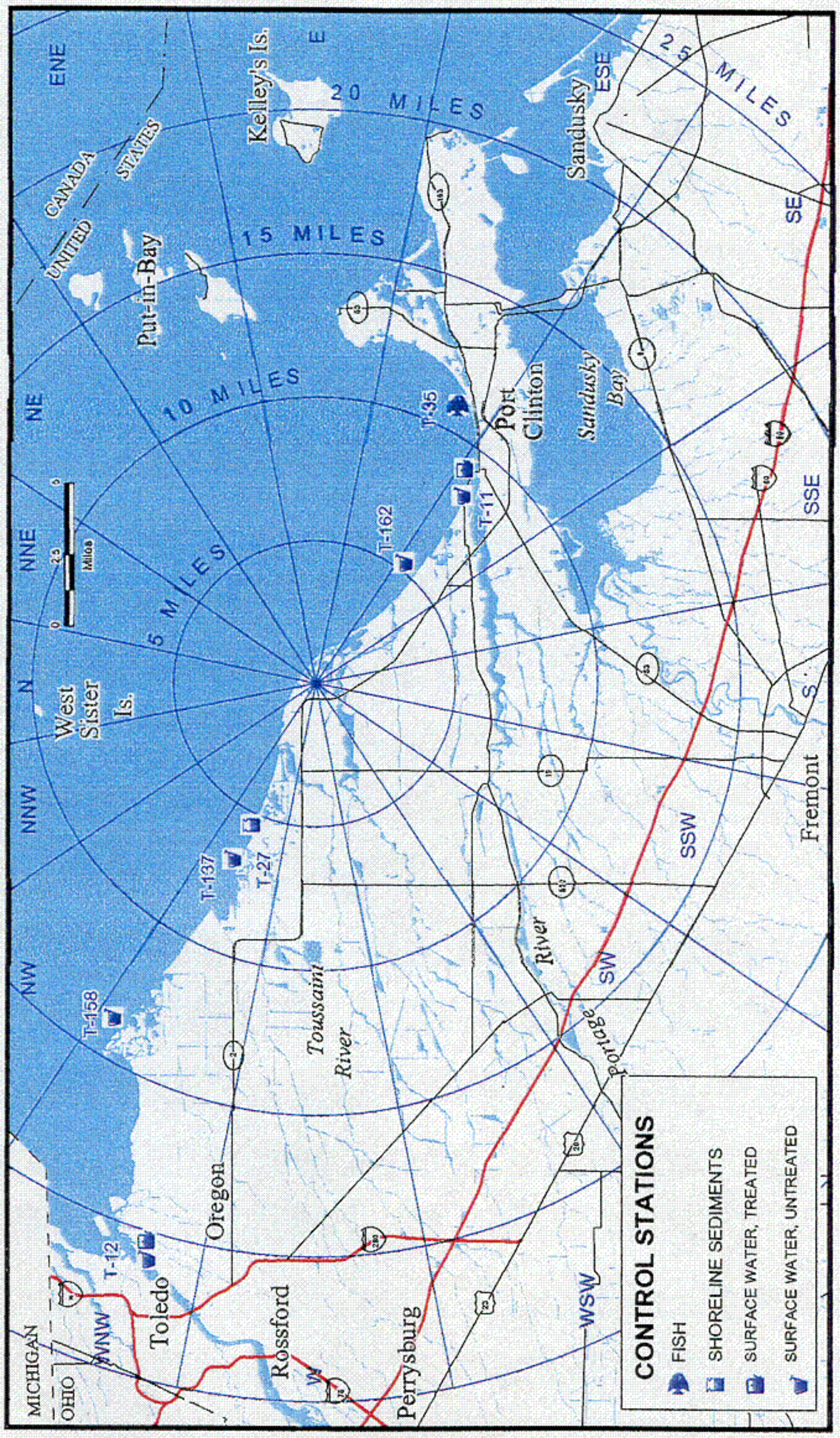


Figure 23: Aquatic 5-mile Map

C10

DAVIS-BESSE NUCLEAR POWER STATION
RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM
AQUATIC SAMPLES: 5-25 MILE RADIUS



ENVIRONMENTAL MONITORING

Figure 24: Aquatic 25-mile Map

C11

Direct Radiation Monitoring

Thermoluminescent Dosimeters

Radionuclides present in the air and deposited on the ground may directly irradiate individuals. Direct radiation levels at and around Davis-Besse are constantly monitored by thermoluminescent dosimeters (TLDs). TLDs are small devices which store radiation dose information. The TLDs used at Davis-Besse contain a calcium sulfate: dysprosium ($CaSO_4$:Dy) card with four main readout areas. Multiple readout areas are used to ensure the precision of the measurements.

Thermoluminescence is a process in which ionizing radiation interacts with phosphor, which is the sensitive material in the TLD. Energy is trapped in the TLD material and can be stored for several months or years. This provides an excellent method to measure the dose received over long periods of time. The energy that was stored in the TLD as a result of interaction with radiation is released and measured by a controlled heating process in a calibrated reading system. As the TLD is heated, the phosphor releases the stored energy in the form of light. The amount of light detected is directly proportional to the amount of radiation to which the TLD was exposed. The reading process re-zeroes the TLD and prepares it for reuse.

TLD Collection

Davis-Besse has 89 TLD locations (78 indicator and 11 control) which are collected and replaced on a quarterly and annual basis. Eighteen QC TLDs are also collected on a quarterly and annual basis. There are a total of 214 TLDs in the environment surrounding Davis-Besse at any given time. By collecting TLDs on a quarterly and annual basis from a single site, each measurement serves as a quality control check on the other. Over 99% of the quarterly TLDs placed in the field and 96% of the annual TLDs placed in the field were retrieved and evaluated during the current reporting period.

In 2001, the average dose equivalent for quarterly TLDs at all indicator locations was 14.4 mrem/91 days, and for all control locations was 14.8 mrem/91 days. The average dose equivalent for annual TLDs in 2001 was 55.6 mrem/365 days at indicator locations and 58.0 mrem/365 days for control locations.

Quality Control TLDs

Duplicate TLDs have been placed at 18 sites. These TLDs were placed in the field at the same time and at the same location as some of the routine TLDs, but were assigned quality control site numbers. This allows us to take several measurements at the location without the laboratory being aware that they are the same. A comparison of the quality control and routine results provides a method to check the accuracy of the measurements. The average dose equivalent at the routine TLDs averaged 14.2 mrem/91 days while the quality control TLDs yielded an average dose equivalent of 13.4 mrem/91 days.

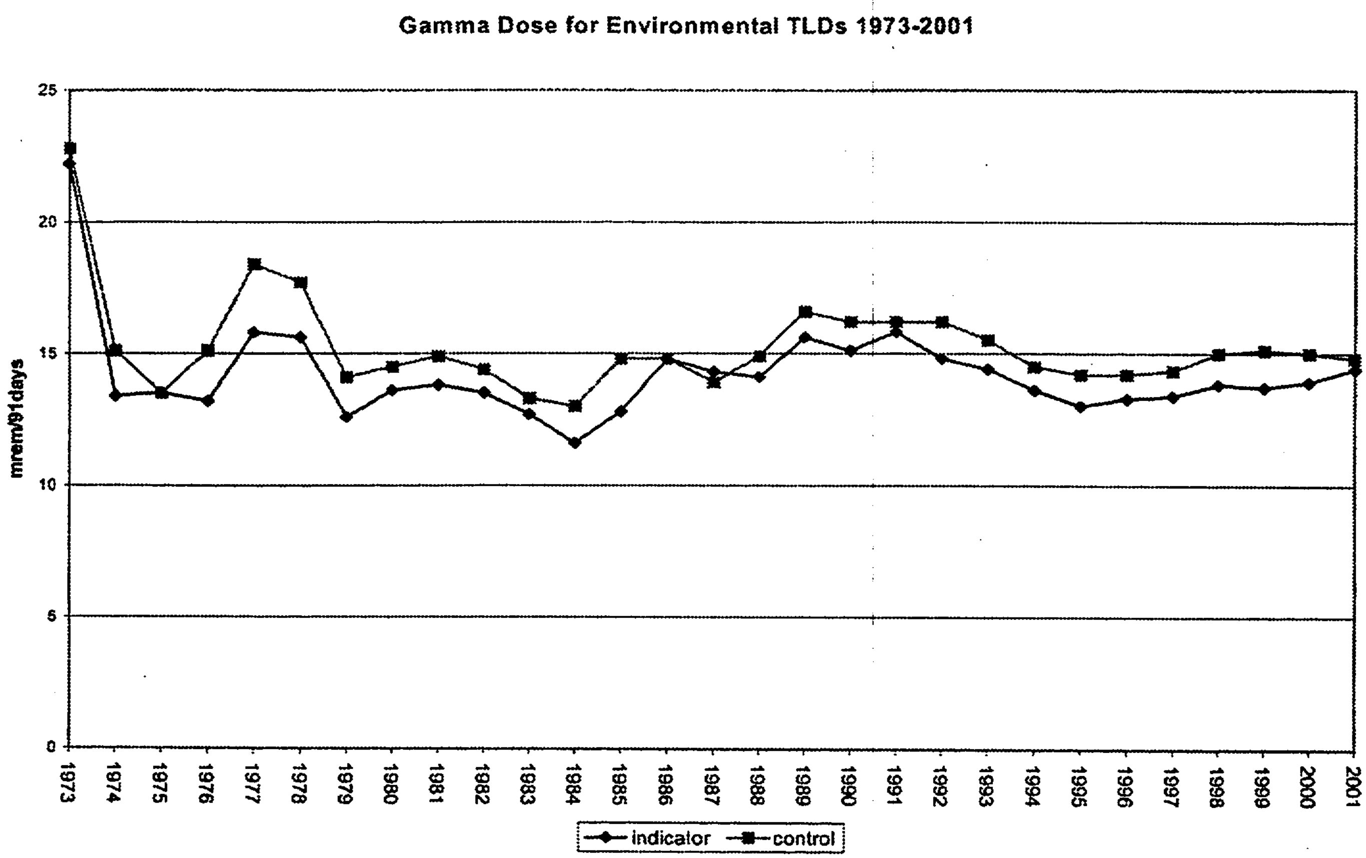


Figure 25: The similarity between indicator and control results demonstrated that the operation of Davis-Besse has not caused any abnormal gamma dose.

Table 16: Thermoluminescent Dosimeter Locations

Sample Location Number	Type of Location	Location Description
T-1	I	Site boundary, 0.6 miles ENE of Station
T-2	I	Site boundary, 0.9 miles E of Station
T-3	I	Site boundary, 1.4 miles ESE of Station
T-4	I	Site boundary, 0.8 miles S of Station
T-5	I	Site boundary, 0.5 miles W of Station
T-6	I	Site boundary, 0.5 miles NNE of Station
T-7	I	Sand Beach, main entrance, 0.9 miles NW of Station
T-8	I	Earl Moore Farm, 2.7 miles WSW of Station
T-9	C	Oak Harbor Substation, 6.8 miles SW of Station
T-10	I	Site boundary, 0.5 miles SSW of Station near warehouse
T-11	C	Port Clinton Water Treatment Plant, 9.5 miles SE of Station
T-12	C	Toledo Water Treatment Plant, 23.5 miles WNW of Station
T-24	C	Sandusky, 21.0 miles SE of Station
T-27	C	Crane Creek State Park, 5.3 miles WNW of Station
T-38	I	Site boundary, 0.6 miles ENE of Station
T-39	I	Site boundary 1.2 miles ENE of Station
T-40	I	Site boundary, 0.7 miles SE of Station
T-41	I	Site boundary, 0.6 miles SSE of Station
T-42	I	Site boundary, 0.8 miles SW of Station

Table 16: Thermoluminescent Dosimeter Locations (continued)

Sample Location Number	Type of Location	Location Description
T-43	I	Site boundary, 0.5 miles SW of Station
T-44	I	Site boundary, 0.5 miles WSW of Station
T-45	I	Site boundary, 0.5 miles WNW of Station
T-46	I	Site boundary, 0.5 miles NW of Station
T-47	I	Site boundary, 0.5 miles N of Station
T-48	I	Site boundary, 0.5 miles NE of Station
T-49	I	Site boundary, 0.5 miles NE of Station
T-50	I	Erie Industrial Park, Port Clinton, 4.5 miles SE of Station
T-51	C	on Siren Pole, 5.5 miles SSE of Station
T-52	I	Miller Farm, 3.7 miles S of Station
T-53	I	Nixon Farm, 4.5 miles S of Station
T-54	I	Weis Farm, 4.8 miles SW of Station
T-55	I	King Farm, 4.5 miles W of Station
T-60	I	Site boundary, 0.3 miles S of Station
T-62	I	Site boundary, 1.0 mile SE of Station
T-65	I	Site boundary, 0.3 miles E of Station
T-66	I	Site boundary, 0.3 miles ENE of Station
T-67	I	Site boundary, 0.3 miles NNW of Station
T-68	I	Site boundary, 0.5 miles WNW of Station
T-69	I	Site boundary, 0.4 miles W of Station

Table 16: Thermoluminescent Dosimeter Locations (continued)

Sample Location Number	Type of Location	Location Description
T-71	I	Site boundary, 0.1 mile NNW of Station
T-73	I	Site boundary, 0.1 mile WSW of Station
T-74	I	Site boundary, 0.1 mile SSW of Station
T-75	I	Site boundary, 0.2 mile SSE of Station
T-76	I	Site boundary, 0.1 mile SE of Station
T-80	QC	Quality Control Site
T-81	QC	Quality Control Site
T-82	QC	Quality Control Site
T-83	QC	Quality Control Site
T-84	QC	Quality Control Site
T-85	QC	Quality Control Site
T-86	QC	Quality Control Site
T-88	QC	Quality Control Site
T-87	QC	Quality Control currently located in lead pig, DBAB annex
T-89	QC	Quality Control Site
T-90	I	Site Personnel Processing Facility
T-91	I	State Route 2 and Rankie Road, 2.5 miles SSE of Station
T-92	I	Locust Point Road, 2.7 miles WNW of Station
T-93	I	Twelfth Street, Sand Beach, 0.6 miles NNE of Station
T-94	I	State Route 2, 1.8 miles WNW of Station
T-95	C	State Route 579, 9.3 miles W of Station

Table 16: Thermoluminescent Dosimeter Locations (continued)

Sample Location Number	Type of Location	Location Description
T-100	C	Ottawa County Highway Garage, Oak Harbor, 6.0 miles S of Station
T-111	C	Toussaint North Road, 8.3 miles WSW of Station
T-112	I	Thompson Road, 1.5 miles SSW of Station
T-113	QC	Quality Control Site
T-114	QC	Quality Control Site
T-115	QC	Quality Control Site
T-116	QC	Quality Control Site
T-117	QC	Quality Control Site
T-118	QC	Quality Control Site
T-119	QC	Quality Control Site
T-120	QC	Quality Control Site
T-121	I	State Route 19, 2.0 miles W of Station
T-122	I	Duff Washa and Humphrey Road, 1.7 miles W of Station
T-123	I	Zetzer Road, 1.6 miles WSW of Station
T-124	C	Church and Walnut Street, Oak Harbor, 6.5 miles SSW of Station
T-125	I	Behlman and Bier Roads, 4.4 miles SSW of Station
T-126	I	Camp Perry Western and Toussaint South Road, 3.7 miles S of Station
T-127	I	Camp Perry Western and Rymers Road, 4.0 miles SSE of Station

Table 16: Thermoluminescent Dosimeter Locations (continued)

Sample Location Number	Type of Location	Location Description
T-128	I	Erie Industrial Park, Port Clinton Road, 4.0 miles SE of Station
T-142	I	Site Boundary, 0.8 miles SSE of Station
T-150	I	Humphrey and Hollywood Road, 2.1 miles NW of Station
T-151	I	State Route 2 and Humphrey Road, 1.8 miles WNW of Station
T-153	I	Leutz Road, 1.4 miles SSW of Station
T-154	I	State Route 2, 0.7 miles SW of Station
T-155	C	Fourth and Madison Streets, Port Clinton, 9.5 miles SE of Station
T-200	QC	Quality Control Site
T-201	I	Sand Beach, 1.1 miles NNW of Station
T-202	I	Sand Beach, 0.8 miles NNW of Station
T-203	I	Sand Beach, 0.7 miles N of Station
T-204	I	Sand Beach, 0.7 miles N of Station
T-205	I	Sand Beach, 0.5 miles NNE of Station
T-206	I	Site Boundary, 0.6 miles NW of Station
T-207	I	Site Boundary, 0.5 miles N of Station
T-208	I	Site Boundary, 0.5 miles NNE of Station.

I = indicator, C = control, QC = quality control

Table 16: Thermoluminescent Dosimeter Locations (continued)

Sample Location Number	Type of Location	Location Description
T-211	I	Site boundary, 0.79 miles E of Station
T-212	I	Site boundary, 1.2 miles ESE of Station
T-213	I	Site boundary, 0.6 miles SSW of Station
T-214	I	Site boundary, 0.7 miles SW of Station
T-215	I	Site boundary, 0.5 miles W of Station
T-216	I	Site boundary, 0.7 miles NW of station
T-217	I	Salem-Carroll Rd., 4.7 miles SSW of Station
T-218	I	Toussaint East Rd., 4.0 miles WSW of Station
T-219	I	Toussaint Portage Rd., 4.8 miles WSW of Station
T-220	I	Duff-Washa Rd., 4.8 miles W of Station
T-221	C	Magee Marsh, 5.1 miles WNW of Station
T-222	I	Turtle Creek Access, 3.7 miles WNW of Station
T-223	I	Lawrence Rd., 5.0 miles SE of Station
T-224	I	Erie Industrial Park, 4.4 miles SE of Station

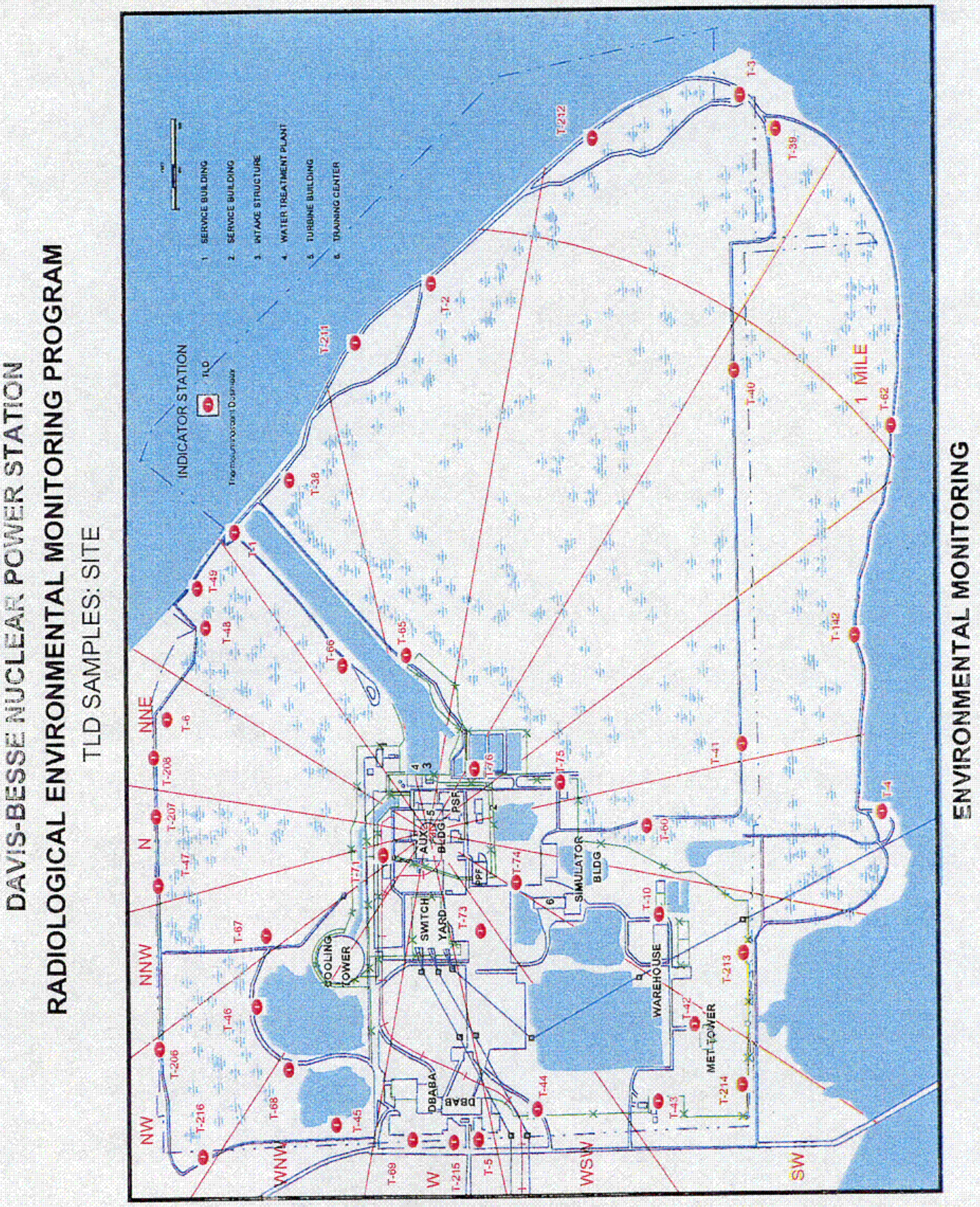


Figure 26: TLD Site Map

C12

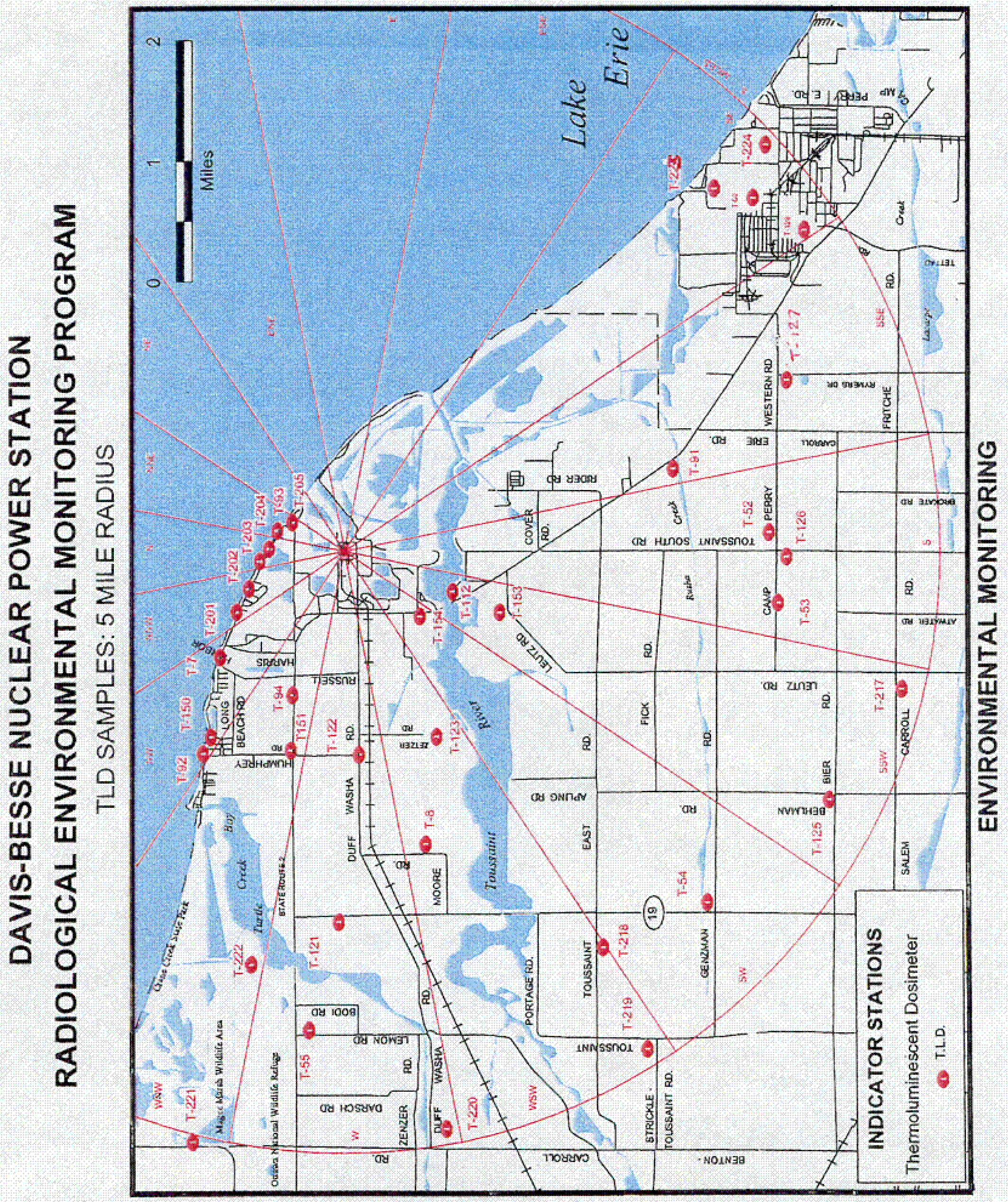


Figure 27: TLD 5-mile Map

C13

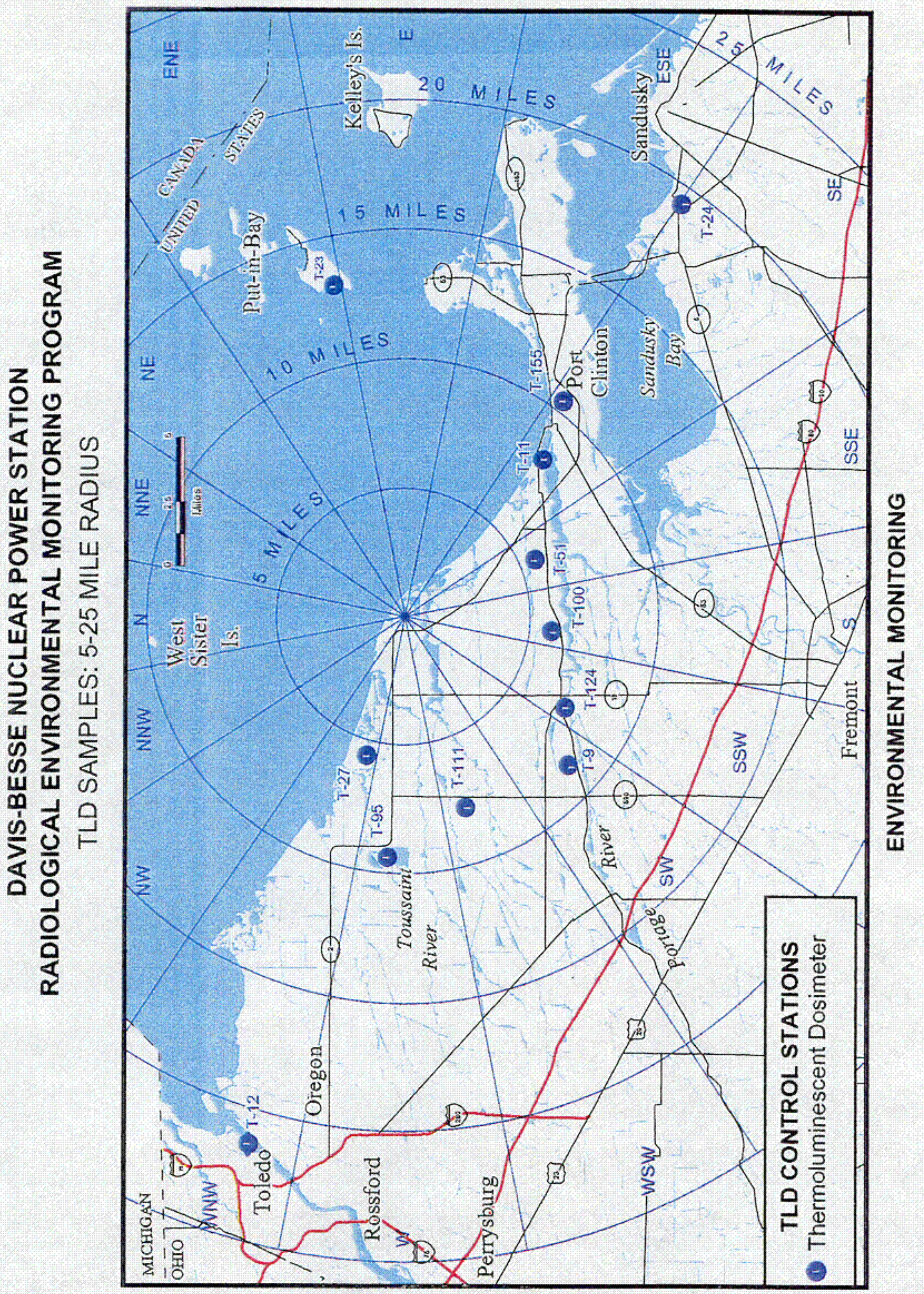


Figure 28: TLD 25-mile Map

C14

Conclusion

The Radiological Environmental Monitoring Program at Davis-Besse is conducted to determine the radiological impact of the Station's operation on the environment. Radionuclide concentrations measured at indicator locations were compared with concentrations measured at control locations in previous operational studies and in the preoperational surveillance program. These comparisons indicate normal concentrations of radioactivity in all environmental samples collected in 2001. Davis-Besse's operation in 2001 indicated no observable adverse radiological impact on the residents and environment surrounding the station. The results of the sample analyses performed during the period of January through December 2001 are summarized in Appendix D of this report.

References

1. "Cesium-137 from the Environment to Man: Metabolism and Dose," Report No.52, National Council on Radiation Protection and Measurement, Washington, D.C. (January 1977).

2. "Environmental Radiation Measurements," Report No.50, National Council on Radiation Protection and Measurement, Washington, D.C. (December 1976).

3. "Exposure of the Population in the United States and Canada from Natural Background Radiation," Report No.94, National Council on Radiation Protection and Measurement, Washington, D.C. (December 1987).

4. "A Guide for Environmental Radiological Surveillance at U.S. Department of Energy Installations," DOE/EP-0023, Department of Energy, Washington, D.C. (July 1981).

5. "Ionizing Radiation Exposure of the Population of the United States," Report No.93, National Council on Radiation Protection and Measurement, Washington, D.C. (September 1987).

6. "Natural Background Radiation in the United States," Report No.45, National Council on Radiation Protection and Measurement, Washington, D.C. (November 1975).

7. "Numerical Guides for Design Objectives and Limiting Conditions for Operation to meet the Criterion 'As Low As Reasonably Achievable' for Radioactive Material in Light Water Cooled Nuclear Power Reactor Effluents," Code of Federal Regulations, Title 10 Energy, Part 50 "Domestic Licensing of Production and Utilization Facilities," Appendix I (1988).

8. "Performance, Testing and Procedural Specifications for Thermoluminescent Dosimetry," American National Standards Institute, Inc., ANSI-N45-1975, New York, New York (1975).

9. "Public Radiation Exposure from Nuclear Power Generation in the United States," Report No.92, National Council on Radiation Protection and Measurement, Washington, D.C. (December 1987).

10. "Radiological Assessment: Predicting the Transport, Bioaccumulation and Uptake by Man of Radionuclides Released to the Environment," Report No.76, National Council on Radiation Protection and Measurement, Washington, D.C. (March 1984).

11. Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants," US NRC (April 1975).

12. Regulatory Guide 4.13, "Performance, Testing, and Procedural Specifications for Thermoluminescent Dosimetry: Environmental Applications," US NRC (July 1977).

13. Regulatory Guide 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operations) - Effluent Streams and the Environment," US NRC (February 1979).

14. Regulatory Guide 0475, "Radiological Environmental Monitoring by NRC Licensees for Routine Operations of Nuclear Facilities," US NRC (September 1978).

15. "Standards for Protection Against Radiation," Code of Federal Regulations, Title 10, Energy, Part 20 (1993).

16. Teledyne Isotopes Midwest Laboratory, "Operational Radiological Monitoring for the Davis-Besse Nuclear Power Station Unit No.1, Oak Harbor, OH," Annual Report, Parts I and II (1977 through 1990).

17. Teledyne Isotopes Midwest Laboratory, "Final Monthly Progress Report to Toledo Edison Company", (1991-1999).

18. Environmental, Inc. Midwest Laboratory, "Final Report to FirstEnergy Corporation", (2000, 2001)

19. Teledyne Isotopes Midwest Laboratory, "Preoperational Environmental Radiological Monitoring for the Davis-Besse Power Station Unit No. 1", Oak Harbor, OH (1972-1977).

20. Toledo Edison Company, "Davis-Besse: Nuclear Energy for Northern Ohio."

21. Toledo Edison Company, "Davis-Besse Nuclear Power Station, Unit No. 1, Radiological Effluent Technical Specifications", Volume 1, Appendix A to License No. NPF-3.

22. Toledo Edison Company, "Final Environmental Statement -Related to the Construction of Davis-Besse Nuclear Power Station," Docket #50-346 (1987).

23. Toledo Edison Company, "Performance Specifications for Radiological Environmental Monitoring Program," S-72N.

24. Toledo Edison Company, "Radiological Environmental Monitoring Program," DB-HP-00015.

25. Toledo Edison Company, "Radiological Environmental Monitoring Quarterly, Semiannual, and Annual Sampling", DB-HP-03004.

26. Toledo Edison Company, "Radiological Monitoring Weekly, Semimonthly, and Monthly Sampling," DB-HP-03005.

27. Toledo Edison Company, "REMP Enhancement Sampling", DB-HP-10101.

28. Toledo Edison Company, "Updated Safety Analysis for the Offsite Radiological Monitoring Program", USAR 11.6, Revision 14, (1992).

29. Toledo Edison Company, "Annual Radiological Environmental Operating Report Preparation and Submittal", DB-HP-00014.

30. Toledo Edison Company, Davis-Besse Nuclear Power Station, Offsite Dose Calculation Manual

31. "Tritium in the Environment", Report No. 62, National Council on Radiation Protection and Measurements, Washington, D.C. (March 1979).