AmerGen
An Exelon/British Energy Company

Clinton Power Station
P.O. Box 678
Clinton, IL 61727
Phone: 217 935-8881

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Washington, D.C. 20555

Subject: Clinton Power Station
Annual Radiological Environmental Operating Report

Dear Madam or Sir:

AmerGen Energy Company, LLC is submitting the 2000 Annual Radiological Environmental Operating Report for Clinton Power Station. This submittal is provided in accordance with the requirements of Section 5.6.2 of the Clinton Power Station Technical Specifications.

Sincerely yours,

R L Gardner (for)

Michael J. Pacilio
Plant Manager

RSF/krk

Attachment

cc: NRC Clinton Licensing Project Manager
NRC Resident Office, V-690
Regional Administrator, Region III, USNRC
Illinois Department of Nuclear Safety

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AmerGen
An Exelon/British Energy Company

Clinton Power Station 2000 Annual Radiological Environmental Operating Report

2000

ANNUAL
RADIOLOGICAL ENVIRONMENTAL OPERATING REPORT

FOR THE
CLINTON POWER STATION

Prepared by

Chemistry Department

TABLE OF CONTENTS

ITEM		PAGE
LIST OF TABLES		iii
LIST OF FIGURES		iv
I. EXECUTIVE SUMMARY		1
II. INTRODUCTION		
A.	Characteristics of Radiation	1
B.	Sources of Radiation Exposure	3
C.	Description of the Clinton Power Station	10
D.	Nuclear Reactor Operations	11
E.	Containment of Radioactivity	15
F.	Sources of Radioactive Effluents	16
G.	Radioactive Waste Processing	17
III. RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM		
A.	Program Description	1
B.	Direct Radiation Monitoring	19
C.	Atmospheric Monitoring	21
D.	Aquatic Monitoring	27
	° Fish	27
	° Shoreline Sediments	28
	° Bottom Sediments	28
	° Aquatic Vegetation (Periphyton)	29
E.	Terrestrial Monitoring	31
	° Milk	31
	° Grass	32
	° Vegetables	32
	° Meat	32
F.	Water Monitoring	33
	° Drinking Water	33
	° Surface Water	33
	° Well Water	34
G.	Quality Assurance Program	36
H.	Changes to the REMP During 2000	37
IV. ANNUAL LAND USE CENSUS		
	2000 Annual Land Use Census	1
V. LIST OF REFERENCES		1

TABLE OF CONTENTS (Cont'd)

ITEM		PAGE
VI.	APPENDICES	
A.	2000 Radiological Environmental Monitoring Program Quality Control Check Results	A-1
B.	REMP Annual Summary	B-1
	1. Sampling and Analysis Frequency Summary	B-3
	2. Radiological Environmental Monitoring Program Annual Summary	B-5
C.	Glossary	C-1
D.	Exceptions to the REMP During 2000	D-1
E.	CPS Radiological Environmental Monitoring Results during 2000	E-1

LIST OF TABLES

TABLE	SUBJECT	PAGE
1	Common Sources of Radiation	II-7
2-A	CPS Radiological Monitoring Program Sampling Locations (TLD Sites)	III-15
2-B	CPS Radiological Monitoring Program Sampling Locations	III-16
3-A	CPS REMP Reporting Levels for Radioactivity Concentrations in Environmental Samples	III-17
3-B	Detection Capabilities for Environmental Sample Analysis Lower Limit of Detection (LLD)	III-17
4	Average Quarterly TLD Results	III-20
5	Annual Average Gross Beta Concentrations in Air Particulates	III-23
6	Average Monthly Gross Beta Concentrations in Air Particulates	III-23
7	Average Gross Beta Concentrations in Drinking, Surface and Well Water	III-36
8	Annual Land Use Census Summary Results	IV-2

LIST OF FIGURES

FIGURE	SUBJECT	PAGE
1	Dose Contributions to the U. S. Population from Principal Sources of Radiation Exposure	II-7
2	Clinton Power Station Basic Plant Schematic	II-13
3	Potential Exposure Pathways of Man Due to Releases of Radioactive Material to the Environment	III-3
4	REMP Sample Locations within 1 Mile	III-7
5	REMP Sample Locations from 1 - 2 Miles	III-9
6	REMP Sample Locations from 2 - 5 Miles	III-11
7	REMP Sample Locations Greater than 5 Miles	III-13
8	Direct Radiation Comparison	III-20
9	Air Particulate Gross Beta Activity Comparison	III-25

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY

This report describes the Annual Radiological Environmental Monitoring Program (REMP) conducted near the Clinton Power Station (CPS) during the 2000 calendar year. The REMP was performed as required by the CPS Operating License issued by the United States Nuclear Regulatory Commission. The objective of the REMP is to assess any radiological impact upon the surrounding environment due to the operation of the Clinton Power Station.

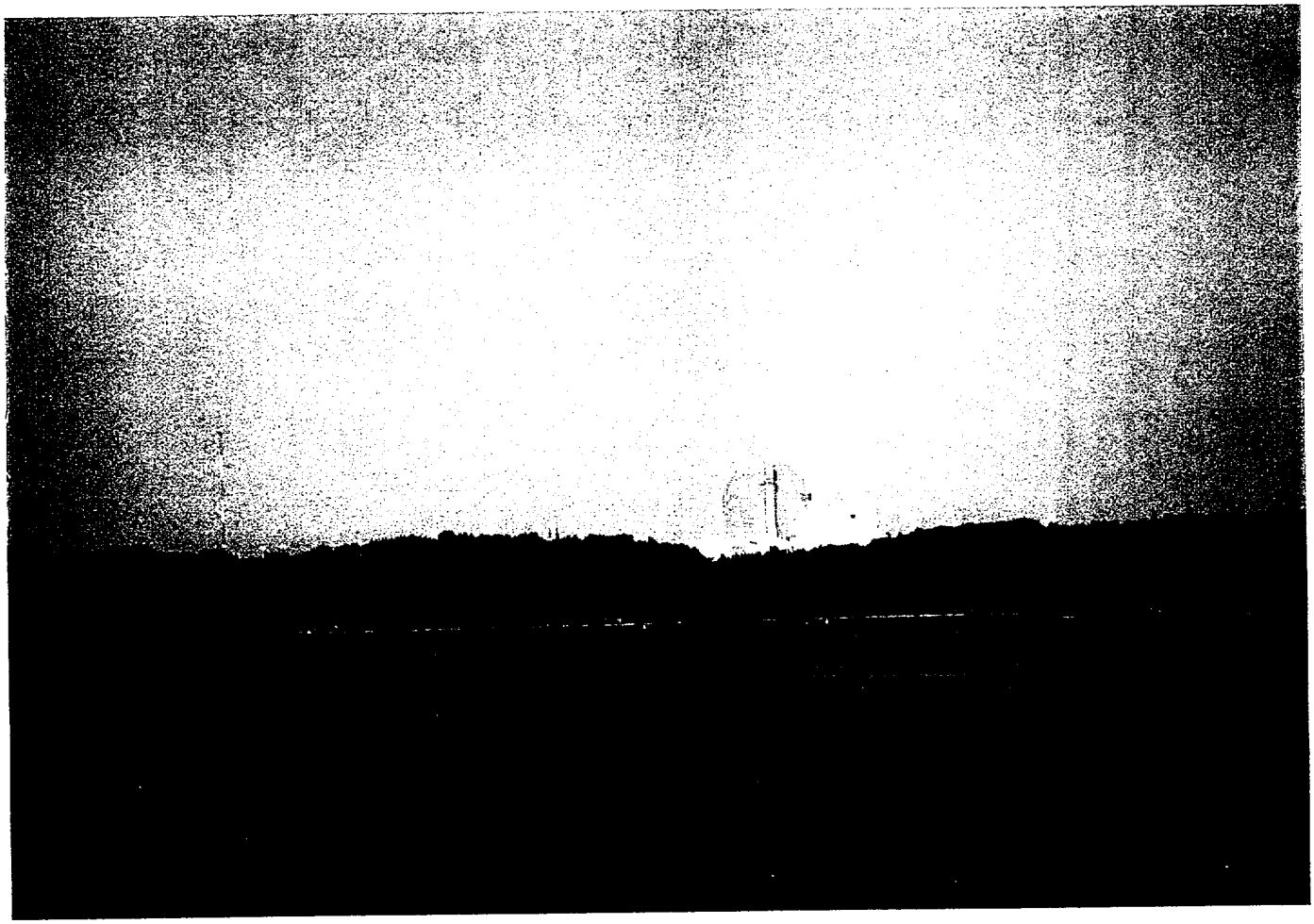
During 2000, over 1,500 environmental samples were collected. These samples represented direct radiation; atmospheric, terrestrial, and aquatic environments; and Clinton Lake surface water and public drinking water supplies. Over 1800 analyses were performed on these environmental samples.

Results of the analyses showed natural radioactivity and radioactivity attributed to other historical nuclear events. The radioactivity levels detected were similar to the preoperational levels. The CPS Preoperational REMP Report documented natural background radionuclides and man-made radioactivity in the environment surrounding CPS prior to plant operations.

Radiological environmental measurements taken during 2000 demonstrated that operational and engineered controls on the radioactive effluents released from the plant functioned as designed. Any radioactivity that was detected in the environment at indicator locations was appropriately compared with both the measurements at control locations (sample locations not affected by station operations) and preoperational results.

There were no radioactive liquid discharges during 2000. Releases of gaseous radioactive materials were accurately measured in plant effluents. There were no gaseous releases that came close to approaching the limits specified in the CPS Offsite Dose Calculation Manual (ODCM). The highest *calculated* offsite dose received by a member of the public due to the release of gaseous materials from Clinton Power Station was less than 0.003 mrem.

All comparisons among operational data and preoperational data showed that the operation of Clinton Power Station had no measurable effect upon the environment in 2000.



INTRODUCTION

II. INTRODUCTION

The Radiological Environmental Monitoring Program at Clinton Power Station is designed to monitor the environment surrounding the plant for any radioactive material that may be released by CPS as a result of plant operations. The primary concern is what impact, if any, the radioactive materials released from CPS have on the general public

A. *CHARACTERISTICS OF RADIATION*

Atoms whose nuclei contain an excess of energy are called radioactive atoms. They release this excess energy by expelling electromagnetic or particulate radiation from their atomic centers to become stable (non-radioactive). This process is called "radioactive decay". X-rays and gamma rays are examples of electromagnetic radiation and are similar in many ways to visible light, microwaves and radio-waves. Particulate radiation may be either electrically charged such as alpha and beta particles, or has no charge, like neutrons.

The term "half-life" refers to the time required for half of a given amount of a radionuclide to decay. Some radionuclides have a half-life as short as a fraction of a second, while others have a half-life as long as a million years. Radionuclides may decay directly into stable elements or may undergo a series of decays that ultimately end up reaching a stable element.

Radionuclides are found in nature (e.g., radioactive uranium, thorium, carbon and potassium), and may also be produced artificially in accelerators and nuclear reactors (e.g., radioactive iodine, cesium and cobalt).

TYPICAL NATURALLY OCCURRING RADIONUCLIDES	TYPICAL MAN-MADE RADIONUCLIDES
Uranium	Iodine
Thorium	Cesium
Carbon	Cobalt
Potassium	Strontium
Lead	Barium

The activity of a radioactive source is the average number of nuclear disintegrations (decay) of the source per unit of time. The unit of activity is called the curie. A one-curie radioactive source undergoes 2.2 trillion disintegrations per minute, but in the realm of

nuclear power plant effluents and environmental radioactivity, this is a large unit. Therefore, two fractional units, the microcurie and the picocurie, are more commonly used.

1 curie (Ci)	=	2,220,000,000,000	disintegrations/minute
1 millicurie (mCi)	=	2,220,000,000	disintegrations/minute
1 *microcurie* (μCi)	=	**2,220,000**	**disintegrations/minute**
1 nanocurie (nCi)	=	2,220	disintegrations/minute
1 *picocurie* (pCi)	=	**2.22**	**disintegrations/minute**

The microcurie (uCi) is one millionth of a curie (Ci) and represents 2.2 million decays per minute. The picocurie (pCi) is one millionth of a microcurie and represents 2.2 decays per minute. Another way of comparing the pCi and the Ci is by analogy with distances. A picocurie would be the width of a pencil mark while a curie would be 100 trips around the earth.

Radioactivity is related to the half-life and the atomic mass of a radionuclide. For example, Uranium-235 (U-235) with a half-life of 704 million years requires about 462,400 grams to obtain an activity of one curie. But iodine-131 (I-131) with a half-life of 8.04 days only requires about 0.000008 grams to produce an activity of one curie.

Any mechanisms that can supply the energy necessary to ionize an atom, break a chemical bond, or alter the chemistry of a living cell are capable of producing biological damage. Electromagnetic and particulate radiation can produce cellular damage in any of these ways. In assessing the biological effects of radiation, the type, energy, and amount of radiation must be considered.

External total body radiation involves exposure of all organs. Most background exposures are of this form. When radioactive elements enter the body through inhalation or ingestion, their distribution may not be uniform.

TARGET TISSUE	NUCLIDE
Bone	Strontium-90
Kidney	Uranium-235
Thyroid	Iodine-131
Muscle and Liver Tissue	Cesium-137
Gastrointestinal Tract	Cobalt-60

For example, radioiodine selectively concentrates in the thyroid gland, whereas radiocesium collects in muscle and liver tissue, and radiostrontium collects in mineralized bone. The total dose to organs by a given radionuclide is also influenced by the quantity and the duration of time that the radionuclide remains in the body. Owing to radioactive decay and human metabolism factors, some radionuclides stay in the body for very short times while others remain for years.

The amount of radiation dose that an individual receives is expressed in rem. Since human exposure to radiation usually involves very small exposures, the millirem (mrem) is the unit most commonly used. One millirem is one thousandth of a rem.

B. SOURCES OF RADIATION EXPOSURE

Many sources of radiation exposure exist. The most common and least controllable source is natural background radiation from cosmic rays and the earth which mankind has always lived with and always will. Every second of our lives, over seven thousand atoms undergo radioactive decay in the body of the average adult.

Radioactive elements have always been a part of our planet and everything that has come from the earth, including our own bodies is, therefore, naturally radioactive.

Natural Radionuclides in the Earth's Crust

Potassium-40	**(K-40)**	**Radium-226**	**(Ra-226)**
Uranium-238	**(U-238)**	**Radon-222**	**(Rn-222)**
Thorium-232	**(Th-232)**	**Lead-204**	**(Pb-204)**

Examples of radioactive materials found in the Earth's crust today consists of radionuclides such as potassium-40, uranium-238, thorium-232, radium-226 and radon-222. These radionuclides are introduced into the water, soil and air by such natural processes as volcanic activity, weathering, erosion and radioactive decay.

Some of the naturally occurring radionuclides, such as radon, are a significant source of radiation exposure to the general public. Radioactive radon is a chemically inert gas produced naturally in the ground as a part of the uranium and thorium decay series. Radon continues to undergo radioactive decay, producing new naturally

radioactive materials called "radon daughters". These new materials, which are solid particles, not gases, can stick to surfaces such as dust particles in the air.

Concentrations of radon in air are variable and are affected by concentrations of uranium and thorium in soil, as well as, altitude, soil porosity, temperature, pressure, soil moisture, rainfall, snow cover, atmospheric conditions, and season. Radon can move through cracks and openings into basements of buildings and become trapped in a small air volume indoors. Thus, indoor radon concentrations are usually higher than those found outdoors. Building materials such as cinder blocks and concrete are radon sources. Radon can also be dissolved in well water and contribute to airborne radon in houses when released through showers or washing.

Dust containing radon daughter particles can be inhaled and deposited on the surface of an individual's lung. Radon daughters emit high-energy alpha radiation dose to the lung lining. Table 1 shows the average annual effective dose due to radon.

About three hundred cosmic rays originating from outer space pass through each person every second.

Cosmic-Ray-Activated Radionuclides

Beryllium-7	**(Be-7)**	**Tritium**	**(H-3)**
Beryllium-10	**(Be-10)**	**Sodium-22**	**(Na-22)**
Carbon-14	**(C-14)**	**Phosphorus-32**	**(P-32)**

The interaction of cosmic rays with atoms in the earth's atmosphere produces radionuclides such as Beryllium-7, Beryllium-10, Carbon-14, tritium, and Sodium-22. Portions of these radionuclides become deposited on land or in water while the remainder stays suspended in the atmosphere.

Consequently, there are natural radioactive materials in the soil, water, air and building materials that contribute to radiation doses to the human body. Natural drinking water contains trace amounts of uranium and radium; milk contains measurable amounts of potassium-40. Sources of natural radiation and their average contributing radiation doses are summarized in Table 1. Figure 1 graphically shows the percentage contribution from principal sources of radiation exposure to the general population of the United States. Radiation exposure levels from natural radiation

fluctuate with time and also can vary widely from location to location. The average individual in the United States receives approximately three hundred mrem per year from natural sources.

In some areas of the country, the dose from natural radiation is significantly higher. Residents of Colorado, five thousand feet above sea level, receive additional dose due to the increase in cosmic and terrestrial radiation levels. In fact, for every one thousand feet in elevation above sea level, an individual will receive an additional one mrem per year from cosmic radiation. In several areas of the world, high concentrations of mineral deposits result in natural background radiation levels of several thousand mrem per year.

In addition to natural background radiation, the average individual is exposed to radiation from a number of man-made sources. The largest of these sources come from medical diagnosis: X-rays, CAT-scans, fluoroscopic examinations and radiopharmaceuticals. Approximately 160 million people in the United States are exposed to medical or dental X-rays in any given year. The annual dose to an individual from such irradiation averages 53 mrem.

TABLE 1

COMMON SOURCES OF RADIATION

A. Average Annual Effective Dose Equivalent to the U.S. Population

1. Natural Sources	mrem
a. Radon	200
b. Cosmic, Terrestrial, Internal	100
2. Man-Made Sources	**mrem**
a. Medical	
X-ray Diagnosis	39
Nuclear Medicine	14
b. Consumer Products	10
c. Occupational	1
d. Miscellaneous Environmental	<1
e. Nuclear Fuel Cycle	<1
Approximate Total	360

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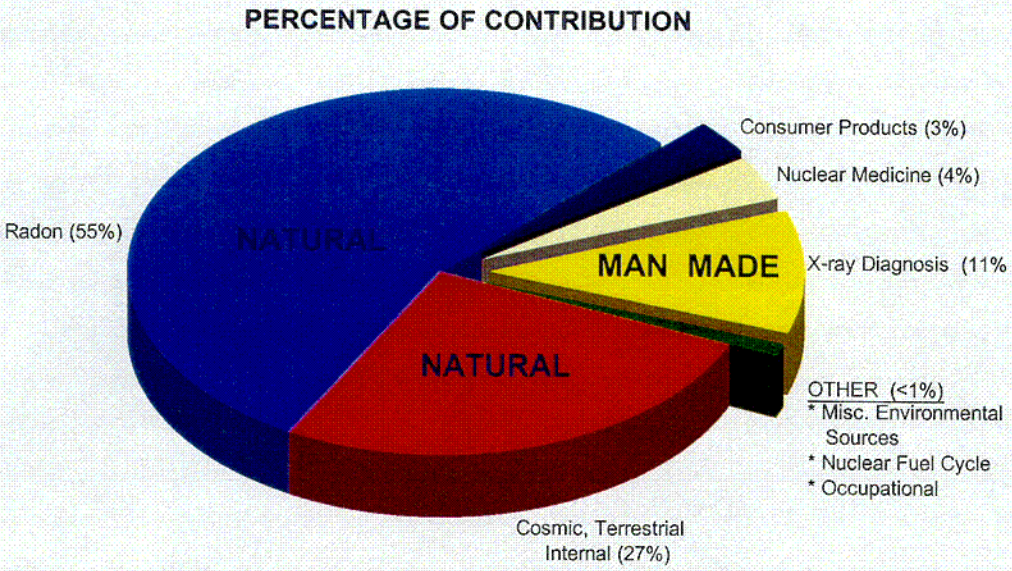

FIGURE 1: DOSE CONTRIBUTIONS TO THE U.S. POPULATION FROM PRINCIPAL SOURCES OF RADIATION EXPOSURE

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Smaller doses from man-made sources come from consumer products (e.g., television, smoke detectors, fertilizers), fallout from prior nuclear weapons tests, and production of nuclear power and its associated fuel cycle.

"Fallout" commonly refers to the radioactive debris that settles to the surface of the earth following the detonation of nuclear weapons. Fallout is dispersed throughout the environment but can be washed down to the Earth's surface by rain or snow.

Radionuclides Found in Fallout

Iodine-131 (I-131) Strontium-90 (Sr-90)
Strontium-89 (Sr-89) Cesium-137 (Cs-137)

There are approximately two hundred radionuclides produced in the nuclear weapon detonation process; a number of these are detected in fallout. The radionuclides found in fallout that produce most of the fallout radiation exposures to man are iodine-131, strontium-89, strontium-90, and cesium-137.

C. *DESCRIPTION OF THE CLINTON POWER STATION*

The Clinton Power Station is located in Harp Township, DeWitt County, Illinois. It is approximately six miles east of Clinton, Illinois.

The station, its V-shaped cooling lake, and the surrounding AmerGen Energy Company LLC (AmerGen) owned land encloses approximately 13,730 acres. This includes the 4,895-acre, man-made cooling lake and about 452 acres of property not owned by AmerGen. The plant is sited on approximately 150 acres on the northern arm of the lake. The cooling water discharge flume, which discharges to the eastern arm of the lake, occupies an additional 130 acres. Although the nuclear reactor, supporting equipment, and associated electrical generation and distribution equipment lie in Harp Township, portions of the 13,730 acres lie in Wilson, Rutledge, DeWitt, Creek, Nixon and Santa Anna Townships.

The cooling lake was formed by constructing an earthen dam near the confluence of Salt Creek and the North Fork of Salt Creek. The resulting lake has an average depth of 15.6 feet, and includes an ultimate heat sink of about 590 acre-feet. The ultimate heat sink provides sufficient water volume and cooling capacity for approximately thirty days of operation without makeup water.

Through arrangements with the Illinois Department of Conservation, Clinton Lake and much of the area immediately adjacent to the lake are used for public recreation activities, including swimming, boating, water-skiing, hunting and fishing. Recreational facilities exist at Clinton Lake and accommodate up to 11,000 people per day during peak usage periods. The outflow from Clinton Lake falls into Salt Creek and flows in a westerly direction for about 56 miles before joining the Sangamon River. The Sangamon River drains into the Illinois River which enters the Mississippi River near Grafton, Illinois. The nearest use of downstream water for drinking purposes is 242 river miles downstream of Clinton Lake at Alton, Illinois, as verified from the Illinois Environmental Protection Agency Public Water Service. Although some farms in the Salt Creek drainage area downstream of Clinton Lake use irrigation, the irrigation water is drawn from wells, not from the waters of Salt Creek.

Approximately 810,000 individuals live within 50 miles of the Clinton Power Station. Over half are located in the major metropolitan centers of Bloomington-Normal (located about 23 miles north northwest), Champaign-Urbana (located about 31 miles east), Decatur (located

about 22 miles south southwest) and Springfield (located about 48 miles west southwest). The nearest city is Clinton, the county seat of DeWitt County. The estimated population of Clinton is about 8,000 people. Outside of the urban areas, most of the land within 50 miles of the Clinton Power Station is used for farming. The principal crops grown are corn and soybeans.

D. *NUCLEAR REACTOR OPERATIONS*

The fuel of a nuclear reactor is made of the element uranium in the form of uranium oxide. The fuel produces power by the process called "fission". In fission, the uranium atom absorbs a neutron and splits to produce fission products, heat, radiation and free neutrons. The free neutrons travel in the reactor core and further absorption of neutrons by uranium permits the fission process to continue. As the fission process continues, more fission products, radiation, heat and neutrons are produced and a sustained reaction occurs. The heat produced is extracted from the fuel to produce steam that drives a turbine generator to produce electricity.

The fission products are predominantly radioactive. They are unstable elements that emit radiation as they change from unstable to stable elements. Neutrons that are not absorbed by the uranium fuel may be absorbed by stable atoms in the materials that make up the components and structures of the reactor. In such cases, stable atoms often become radioactive. This process is called "activation" and the radioactive atoms which result are called "activation products".

Fission Products		*Activation Products*	
Cesium-137	**(Cs-137)**	**Cobalt-60**	**(Co-60)**
Barium-140	**(Ba-140)**	**Manganese-54**	**(Mn-54)**
Cerium-144	**(Ce-144)**	**Iron-59**	**(Fe-59)**
Strontium-90	**(Sr-90)**	**Zinc-65**	**(Zn-65)**

The reactor at the Clinton Power Station is a boiling water reactor (BWR). Figure 2 provides a basic plant schematic for the Clinton Power Station and shows the separation of the cooling water from plant systems. In this type of reactor the fuel is formed into small ceramic pellets that are loaded into sealed fuel rods.

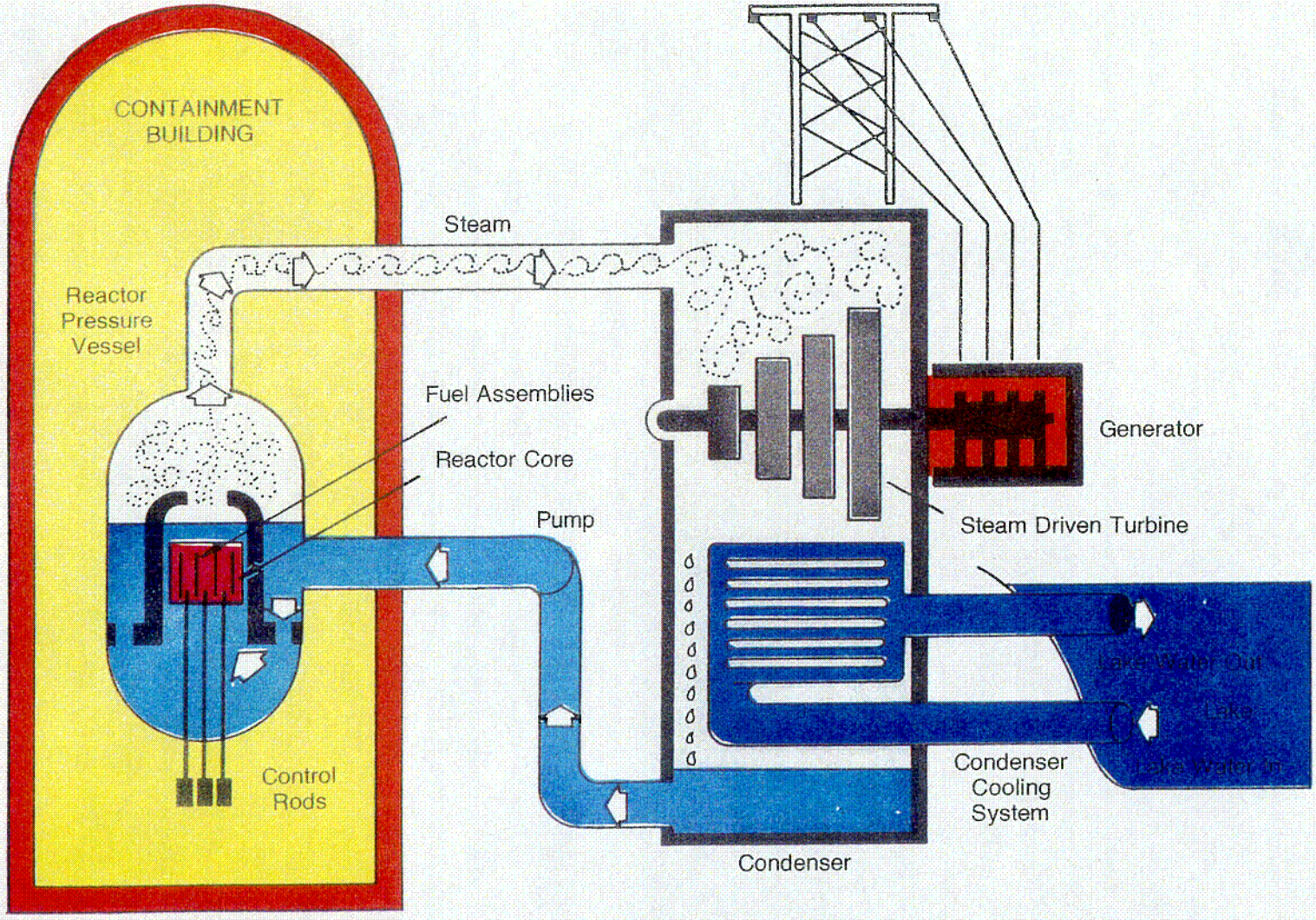

FIGURE 2: CLINTON POWER STATION BASIC PLANT SCHEMATIC

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The fuel rods are arranged in arrays called bundles that are supported within a massive steel reactor vessel.

The spaces between the fuel rods are filled with water. The heat released during the fission of fuel atoms is transferred to the water surrounding the fuel rods. A type of pump that contains no moving parts (a jet pump), and recirculation pumps are used to force the water to circulate through the fuel bundles to assure even cooling of the fuel rods. As the water absorbs heat from the fuel rods some of it is changed to steam. The steam is used to drive a turbine that is coupled to a generator, thereby completing the conversion of the energy released during fission to electricity.

After the steam passes through the turbine it is condensed back to water and returned to the reactor vessel to repeat the process. As the water circulates through the reactor pressure vessel, corrosion allows trace quantities of the component and structure surfaces to get into the water. The corroded material also contains radioactive substances known as activated corrosion products. Radioactive fission and activation products are normally confined to the primary system although small leaks from the primary system may occur.

E. CONTAINMENT OF RADIOACTIVITY

During operating conditions, essentially all radioactivity is contained within the first of several barriers that collectively prevent escape of radioactivity to the environment.

The fuel cladding (metal tubes) provides the first barrier. The ceramic fuel pellets are sealed within zircaloy metal tubes. There is a small gap between the fuel and the cladding where the noble gases and volatile nuclides collect.

The reactor pressure vessel and the steel piping of the primary coolant system provide the second barrier. The reactor pressure vessel is a seventy-foot high vessel with steel walls ranging from four to seven inches thick that encases the reactor core. The reactor pressure vessel and the steel piping provide containment for all radionuclides in the primary coolant.

The Containment Building provides the third barrier. The Containment Building has steel-lined, four-foot-thick reinforced concrete walls which completely enclose the reactor pressure vessel and vital auxiliary equipment. This structure provides a third line of

defense against the uncontrolled release of radioactive materials to the environment. The massive concrete walls also serve to absorb much of the radiation emitted during reactor operation or from radioactive materials created during reactor operations.

F. SOURCES OF RADIOACTIVE EFFLUENTS

In an operating nuclear power plant, most of the fission products are retained within the fuel and fuel cladding. However, the fuel manufacturing process leaves traces of uranium on the exterior of the fuel tubes. Fission products from the eventual fission of these traces may be released to the primary coolant. Other small amounts of radioactive fission products are able to diffuse or migrate through the fuel cladding and into the primary coolant. Trace quantities of the corrosion products from component and structural surfaces that have been activated, also get into the primary coolant.

Many soluble fission and activation products such as radioactive iodines, strontiums, cobalts and cesiums are removed by demineralizers in the water purification systems. The noble gas fission products, activated atmospheric gases introduced with reactor feedwater, and some of the volatile fission products such as iodine and bromine, are carried from the reactor pressure vessel to the condenser with the steam.

The steam jet air ejectors or the condenser vacuum pump remove the gases from the condenser and transfer them to the off-gas treatment system. In the off-gas treatment system, the gases are held up by adsorption on specially treated charcoal beds to allow radioactive gases to decay before they are released through the main ventilation exhaust stack.

Small releases of radioactive liquids from valves, piping, or equipment associated with the primary coolant system may occur in the Containment, Auxiliary, Turbine, RadWaste and Fuel Buildings. The noble gases become part of the gaseous wastes while the remaining radioactive liquids are collected in sumps and processed for reuse. Processed primary coolant water that does not meet chemical specifications for reuse may also become wastewater. These represent the principal sources of liquid effluents.

Information about radioactive effluents can be found in the Annual Effluent Release Report. This report contains a detailed description of all radioactive releases from CPS and the resulting radiation doses for the reporting period.

G. *RADIOACTIVE WASTE PROCESSING*

In a normal operating nuclear power plant, radioactive liquid and gaseous wastes are collected, stored and processed through treatment systems to remove or reduce most of the radioactivity (excluding tritium) prior to reuse within the plant or discharge to the environment. These processing systems are required by the Clinton Power Station Offsite Dose Calculation Manual to be installed and operable to help ensure all releases of radioactive liquid and gaseous effluents are As Low As Reasonably Achievable (ALARA). *As a matter of commitment, CPS strives to be a zero liquid discharge plant.*

The liquid waste treatment systems consist of filters, demineralizers and evaporators. Liquid wastes are routed through the waste evaporators to be degassed and distilled thereby reducing their volume and concentrating their radioactivity. The distillates are further treated through demineralizers and filters and transferred to the waste evaporator condensate storage tanks. Liquid wastes are processed through the appropriate portions of the liquid waste treatment system to provide assurance that the releases of radioactive materials in liquid effluents will be kept ALARA.

Liquid wastes may be discharged into the plant cooling water stream which varies from approximately 5,000 gallons per minute, when the plant is in shutdown, to 567,000 gallons per minute, when the plant is at full power. If discharged, liquid effluents are thoroughly mixed with and diluted by the plant cooling water as it travels the 3.4 miles of the discharge canal before it enters Clinton Lake east of DeWitt County Road 14.

The Clinton Power Station Offsite Dose Calculation Manual requires that liquid effluents not contain a higher concentration of any radioisotope than that which is set for continuous exposure to the general public. This condition is satisfied at the point the liquid effluent is first introduced into the cooling water flow. The additional dilution that occurs in the cooling water canal reduces the concentrations of radioisotopes to between 1/73 (for minimum flow) and 1/1890 (for maximum flow) of their original value before the water enters Clinton Lake.

The concentrated radioactive solids captured in the liquid waste treatment system are processed and stored on-site or shipped off-site for disposal at licensed low-level waste disposal facilities.

The gaseous effluents from the main condenser are held up in the off-gas charcoal beds for at least 46 hours. This provides time for the decay of most of the radionuclides present since most have a half-life of less than 8 hours. If gaseous effluents in the ventilation exhaust system for the Containment Building and for the Secondary Containment structure exceed conservatively set levels, they are processed through charcoal beds and high efficiency particulate air filters in the Standby Gas Treatment System before being discharged to the environment.

This combination of filters and charcoal beds is rated to be 95% efficient for removing iodines and greater than 99% efficient for removing particulate material larger than one micron (one millionth of an inch) in diameter.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

III.

RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM

A. Program Description

The Clinton Power Station is required to maintain a radiological environmental monitoring program in accordance with the Code of Federal Regulations (CFR) Title 10, Section 20.1501 and Criterion 64 of CFR Title 10, Part 50, Appendix A. The program was developed using the following guidance published by the United States Nuclear Regulatory Commission (USNRC):

- Regulatory Guide 4.1, "Programs for Monitoring Radioactivity in the Environs of Nuclear Power Plants"
- USNRC Radiological Assessment Branch Technical Position on Radiological Environmental Monitoring (1979)

The Radiological Environmental Monitoring Program is an extensive program of sampling, measuring and analyzing that was instituted to monitor the radiological impact of reactor operation on the environment. Objectives of the program include:

- identification, measurement and evaluation of existing radionuclides in the environs of the Clinton Power Station and fluctuations in radioactivity levels which may occur
- evaluation of the measurements to determine the impact of Clinton Power Station operations on the local radiation environment
- collection of data needed to refine environmental radiation transport models used in offsite dose calculations
- verification that radioactive material containment systems are functioning to minimize environmental releases to levels that are ALARA
- demonstration of compliance with regulations and the Clinton Power Station Offsite Dose Calculation Manual.

Implicit in these objectives are the requirements to trend and assess radiation exposure rates and radioactivity concentrations in the environment that may contribute to radiation exposure to the public. The program consists of two phases, preoperational (preop) and operational.

The preoperational portion of the program was initiated in May, 1980 and was completed on February 27, 1987 to establish the baseline for the local radiation environment. Assessment of the operational impact of the Clinton Power Station on the radiation environment is based on data collected since the beginning of reactor operation. The operational phase implements confirmatory measurements to verify that the in-station controls for the release of radioactive material are functioning as designed.

AmerGen Company maintains a contract with Environmental Inc. Midwest Laboratory, for analysis of all radiological environmental samples. Environmental Inc. is located in Northbrook, Illinois. Samples are collected by AmerGen Company personnel and shipped to the laboratory for analysis. After analysis, environmental samples are saved at the laboratory for a specified period of time in case additional analysis is required. Analytical results are reported monthly to company radiation protection personnel.

Current regulatory guidance recommends evaluating direct pathways, or the highest trophic level in a dietary pathway, that contribute to an individual's dose. Figure 3 shows the basic pathways of gaseous and liquid radioactive effluents to an individual. The "important pathways" selected are based primarily on how radionuclides move through the environment and eventually expose individuals, as well as man's use of the environment. The scope of the program includes the monitoring of five environmental compartments:

- direct radiation
- atmospheric
- aquatic
- terrestrial environments
- ground and surface water.

Each pathway is monitored at "indicator" and "control" locations. Indicator locations are generally within the 10-mile radius of the station and at locations that are expected to manifest station effects, if any exist. Control locations are located at least ten miles from the plant, far enough to be unaffected by plant operations. These control samples provide a basis by which to evaluate fluctuations in radioactivity at indicator locations in relation to natural phenomena and fallout. An increase in dose rate or radioactive material concentration at an indicator location may be due to plant operations.

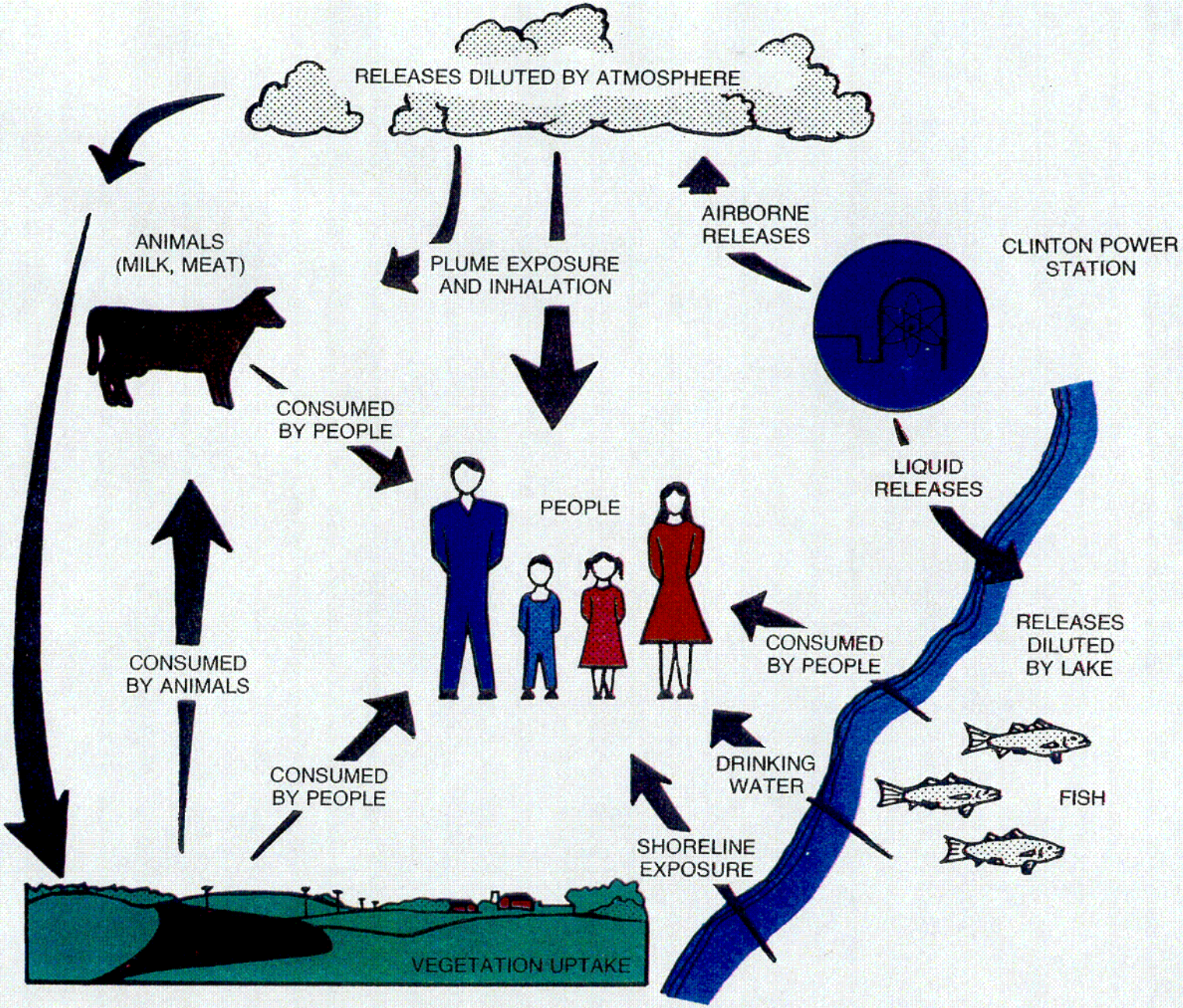


FIGURE 3: POTENTIAL EXPOSURE PATHWAYS OF MAN DUE TO RELEASES OF RADIOACTIVE MATERIAL TO THE ENVIRONMENT

Sampling locations were established by considering site meteorology, population distribution, site hydrology, and land use characteristics of the local area. These locations were selected primarily on the basis of where the highest predicted environmental concentrations would occur.

Locations of sampling stations are shown on maps in Figures 4 through 7. Table 2 provides information on sample location, media sampled at each location, and a brief description of each location where samples are taken. The location is listed according to distance (in miles) and the compass sector relative to the Station Heating, Ventilation and Air Conditioning (HVAC) stack.

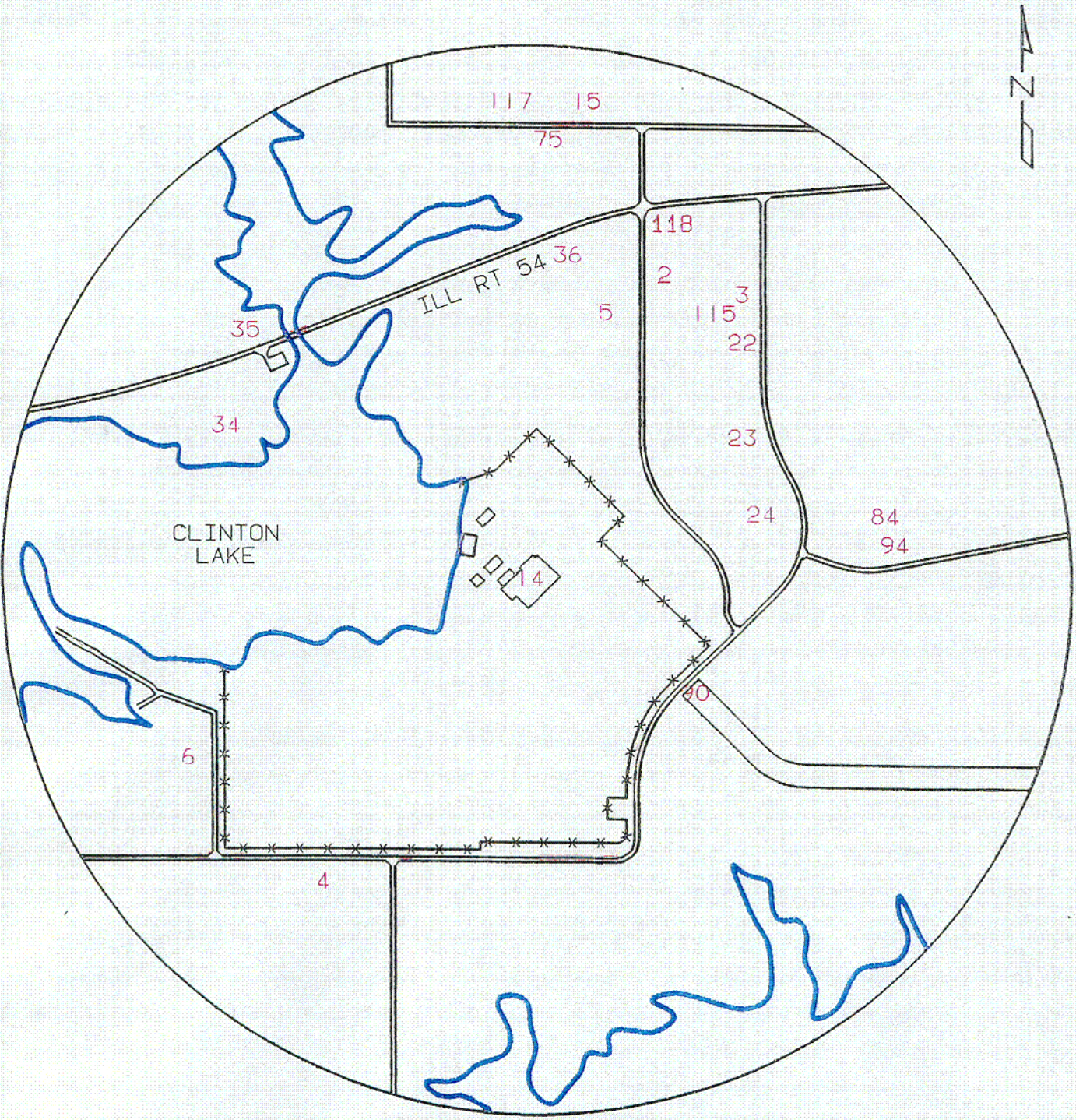


FIGURE 4: REMP SAMPLE LOCATIONS WITHIN 1 MILE

C04

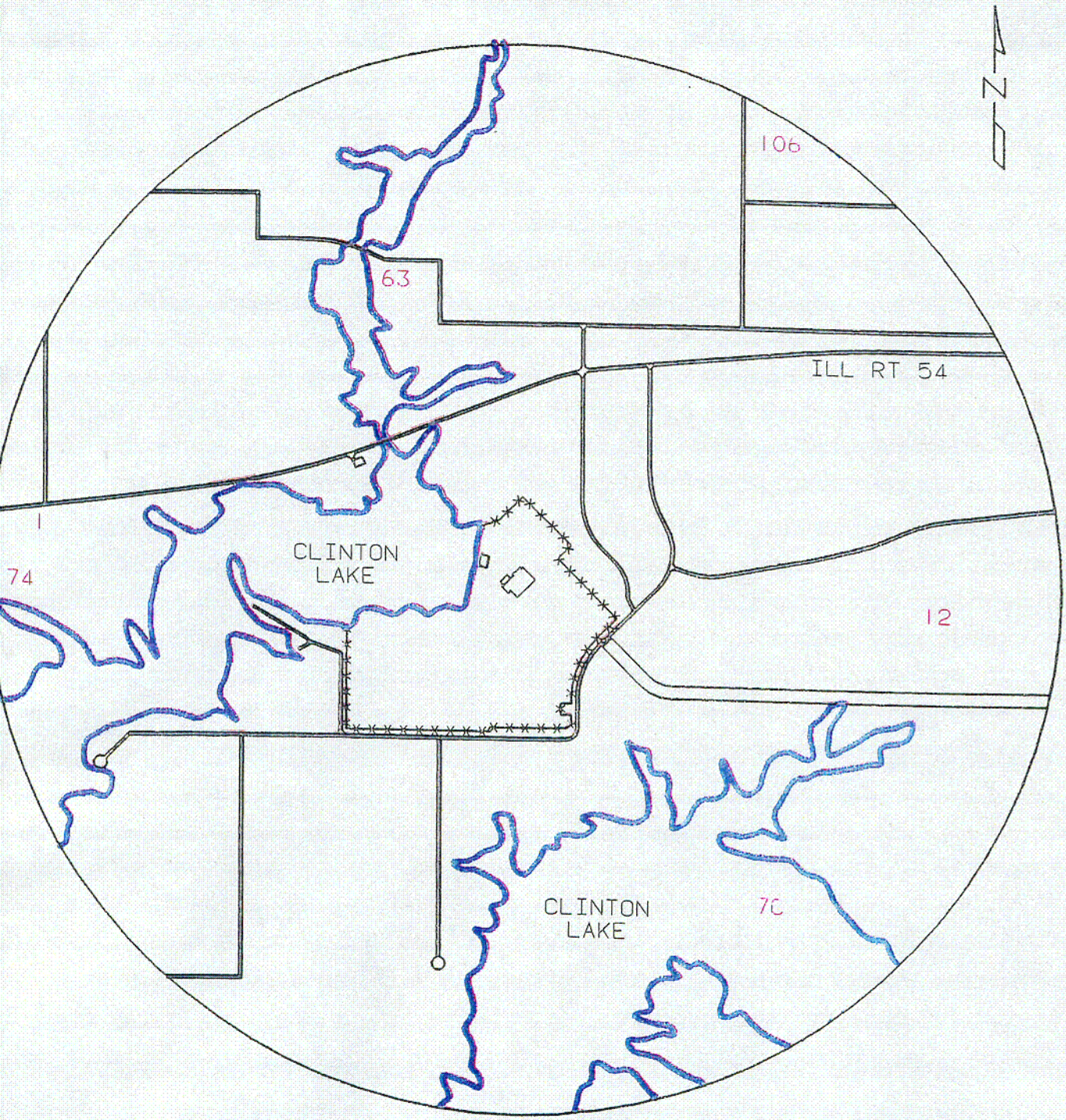


FIGURE 5: REMP SAMPLE LOCATIONS FROM 1 - 2 MILES

C05

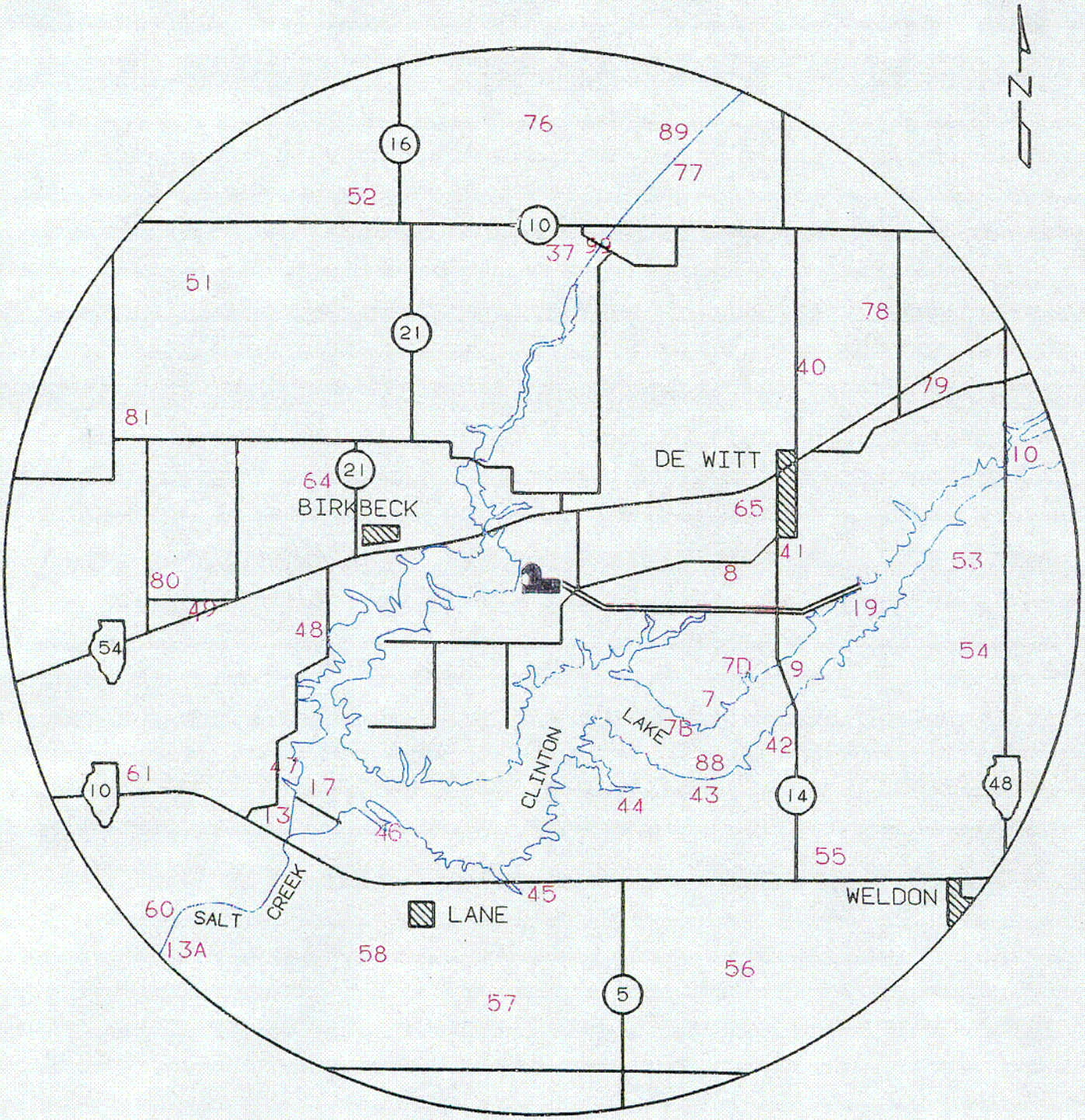


FIGURE 6: REMP SAMPLE LOCATIONS FROM 2 - 5 MILES

C06

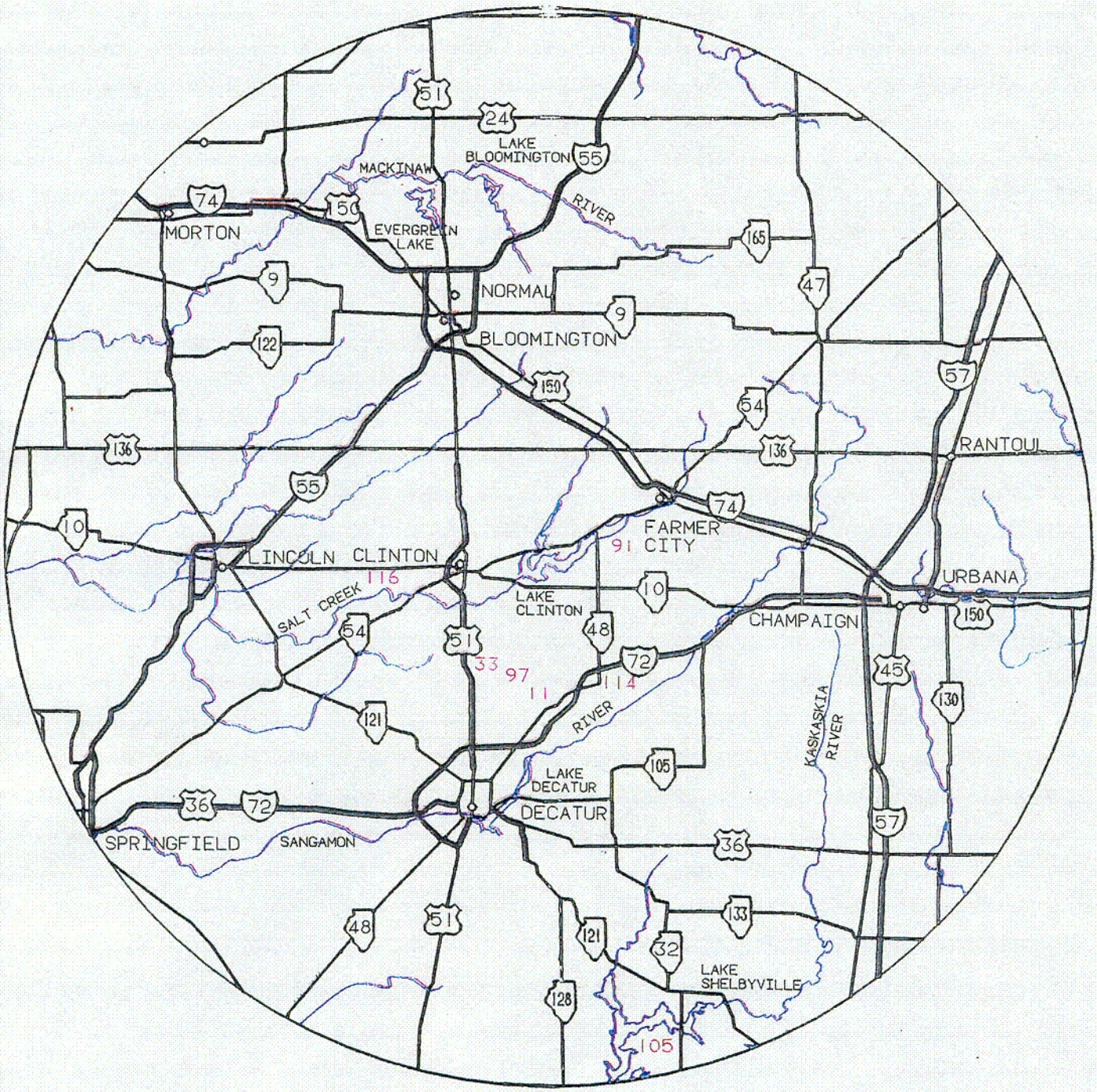


FIGURE 7: REMP SAMPLE LOCATIONS GREATER THAN 5 MILES

C07

TABLE 2-A

CPS RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLING LOCATIONS

TLD Sites

Station Code	Description	Sector	Distance (miles)
CL-1	inner ring	W	1.8
CL-2	supplemental	NNE	0.7
CL-3	supplemental	NE	0.7
CL-4	supplemental	SW	0.8
CL-5	inner ring	NNE	0.7
CL-6	supplemental	WSW	0.8
CL-7	supplemental	SE	2.3
CL-8	supplemental	E	2.2
CL-11	control	S	16
CL-15	supplemental	N	0.9
CL-22	inner ring	NE	0.6
CL-23	inner ring	ENE	0.5
CL-24	inner ring	E	0.5
CL-33	supplemental	SW	11.7
CL-34	inner ring	WNW	0.8
CL-35	inner ring	NW	0.7
CL-36	inner ring	N	0.6
CL-37	special interest	N	3.4
CL-41	special interest	E	2.4
CL-42	inner ring	ESE	2.8
CL-43	inner ring	SE	2.8
CL-44	inner ring	SSE	2.3
CL-45	inner ring	S	2.8
CL-46	inner ring	SSW	2.8
CL-47	inner ring	SW	3.3
CL-48	inner ring	WSW	2.3
CL-49	special interest	W	3.5

Station Code	Description	Sector	Distance (miles)
CL-51	outer ring	NW	4.4
CL-52	outer ring	NNW	4.3
CL-53	outer ring	E	4.3
CL-54	outer ring	ESE	4.6
CL-55	outer ring	SE	4.1
CL-56	outer ring	SSE	4.1
CL-57	outer ring	S	4.6
CL-58	outer ring	SSW	4.3
CL-60	outer ring	SW	4.5
CL-61	outer ring	WSW	4.5
CL-63	inner ring	NNW	1.3
CL-64	special	WNW	2.1
CL-65	special	ENE	2.6
CL-74	special	W	1.9
CL-75	special	N	0.9
CL-76	outer ring	N	4.6
CL-77	outer ring	NNE	4.5
CL-78	outer ring	NE	4.8
CL-79	outer ring	ENE	4.5
CL-80	outer ring	W	4.1
CL-81	outer ring	WNW	4.5
CL-84	supplemental	E	0.6
CL-90	supplemental	SE	0.4
CL-91	supplemental	ENE	6.1
CL-97	supplemental	SSW	10.3
CL-99	supplemental	NNE	3.5
CL-114	supplemental	SSE	12.5

TABLE 2-B

CPS RADIOLOGICAL ENVIRONMENTAL MONITORING PROGRAM SAMPLING LOCATIONS

Station Code	Description	Air	Surface Water	Drinking Water	Food Products	Milk	Ground Water
CL-1	Camp Quest (1.8 mi W)	●					
CL-2	Site's main access road (0.7 mi NNE)	√					
CL-3	Site's secondary access road (0.7 mi NE)	√					
CL-4	Residence near recreation area (0.8 mi SW)	●					
CL-6	CPS recreation area (0.8 mi WSW)	●					
CL-7	Mascoutin Recreation Area (2.3 mi SE)	●					
CL-7D	Mascoutin Recreation Area (2.3 mi ESE)						√
CL-8	DeWitt Cemetery (2.2 mi E)	√					
CL-11*	Illinois Power substation (16 mi S)	√					
CL-12	DeWitt pumphouse (1.6 mi E)						√
CL-13	Salt Creek bridge on Rt.10 (3.6 mi SW)		●				
CL-14	Site service building			√			
CL-15	Near residence on Rt. 900N (0.9 mi N)	√					
CL-90	Start of discharge flume (0.4 mi SE)		√				
CL-91	Parnell Boat Access (6.1 mi ENE)		√				
CL-94	Old Clinton Road (0.6 mi E)	●					
CL-99	North Fork canoe access area (3.5 mi NNE)		●				
CL-106	Pasture (2.0 mi NNE)				●		
CL-114*	Residence in Cisco (12.5 mi SSE)				√		
CL-115	Site's secondary access road (0.7 mi NE)				√		
CL-116	Pasture in rural Kenney (14 mi WSW)					√	
CL-117	Resident north of site (0.9 mi N)				√		
CL-118	Site's main access road (0.7 mi NNE)				√		

Station Code	Description	Grass	Fish	Periphyton	Shoreline Sediment	Bottom Sediments
CL-1	Camp Quest (1.8 mi W)	●				
CL-2	Site's main access road (0.7 mi NNE)	●				
CL-7B	SE of site on Clinton Lake (2.1 mi SE)			●	√	
CL-7C	Mascoutin Recreation Area (1.3 mi SE)			●	●	●
CL-8	DeWitt Cemetery (2.2 mi E)	●				
CL-9	DeWitt County Rt.14 bridge (2.7 mi ESE)			●		
CL-10	Illinois Rt.48 bridge (5.0 mi ENE)			●	●	●
CL-13A	Salt Creek bridge on Rt.10 (5.0 mi SW)					●
CL-17	Near the Clinton Lake Dam (3.5 mi SW)					●
CL-19	End of the discharge flume (3.4 mi E)		√	●	●	●
CL-88	Located SE of site (2.4 mi SE)				●	
CL-89	Located NNE of site (3.6 mi NNE)				●	●
CL-105*	Lake Shelbyville (50 mi S)		√	●	●	●
CL-116	Pasture in rural Kenney (14 mi WSW)	●				

*** Control Location** √ ODCM required samples ● Supplemental samples

Note: Location is listed by distance in miles and directional sector from the Station HVAC stack.

TABLE 3-A

CPS REMP REPORTING LEVELS FOR RADIOACTIVITY CONCENTRATIONS IN ENVIRONMENTAL SAMPLES[d]

Analysis	Water (pCi/l)	Airborne Particulate or Gases (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)
H-3	20,000[a]	---	---	---	---
Mn-54	1,000	---	30,000	---	---
Fe-59	400	---	10,000	---	---
Co-58	1,000	---	30,000	---	---
Co-60	300	---	10,000	---	---
Zn-65	300	---	20,000	---	---
Zr-Nb-95	400[c]	---	---	---	---
I-131	2[b]	0.9	---	3	100
Cs-134	30	10	1,000	60	1,000
Cs-137	50	20	2,000	70	2,000
Ba-La-140	200[c]	---	---	300	---

a If no drinking water pathway exists, a value of 30,000 pCi/l may be used.
b If no drinking water pathway exists, a value of 20 pCi/l may be used.
c Total for parent and daughter.
d This list does not mean these nuclides are the only ones considered. Other nuclides are identified and reported when applicable.

TABLE 3-B

DETECTION CAPABILITIES FOR ENVIRONMENTAL SAMPLE ANALYSIS LOWER LIMIT OF DETECTION (LLD)

Analysis	Water (pCi/l)	Airborne Particulate or Gas (pCi/m^3)	Fish (pCi/kg, wet)	Milk (pCi/l)	Food Products (pCi/kg, wet)	Sediment (pCi/kg, dry)
Gross Beta	4	0.01				
H-3	2000*					
Mn-54	15		130			
Fe-59	30		260			
Co-58, 60	15		130			
Zn-65	30		260			
Zr-95	30					
Nb-95	15					
I-131	1**	0.07		1	60	
Cs-134	15	0.05	130	15	60	150
Cs-137	18	0.06	150	18	80	180
Ba-140	60			60		
La-140	15			15		

* If no drinking water pathway exists, a value of 3000 pCi/l may be used.
** If no drinking water pathway exists, a value of 15 pCi/l may be used.

Sample Analysis

Concentrations of radioactivity present in the environment will vary due to factors such as weather or variations in sample collection techniques or sample analysis.

Several types of measurements may be performed to provide information about the types of radiation and radionuclides present. Analyses that are performed on environmental samples collected for the CPS REMP include:

- Gross alpha and beta analysis
- Gamma spectroscopy analysis
- Tritium analysis
- Strontium analysis
- Gamma dose (TLDs only)

Gross alpha and beta analyses measures the total amount of alpha and beta emitting radioactivity present in a sample. Both radiations may be released by many different radionuclides. Gross activity measurements, while useful as general trend indicators, are not used to establish specific radionuclide concentrations. Therefore, gross activity analysis only indicates whether the sample contains normal or abnormal concentrations of alpha or beta emitting radioactivity and acts as a tool used to identify samples that may require further analysis.

Samples are primarily analyzed for plant-contributed radionuclides released to the environment. Since naturally occurring radionuclides are abundant in environmental samples, positive results for certain radionuclides and gross alpha/beta measurements are discussed in some cases in this section of the report.

B. Direct Radiation Monitoring

Radionuclides present in the air, and those deposited in or on the ground cause human exposure by immersion in the atmosphere or by deposition on the ground. TLDs (thermoluminescent dosimeters) are used to measure the ambient gamma radiation field at many locations around the Clinton Power Station.

TLDs are crystalline devices that store energy when they are exposed to radiation. They can be processed months after exposure with minimal loss of information. This makes them well suited for quarterly environmental radiation measurements.

During processing, the stored energy is released as light and measured by a TLD reader. The light intensity is proportional to the radiation dose the TLD received. The TLDs used in monitoring around the Clinton Power Station are easily capable of measuring environmental levels of radiation, approximately 20 mrem per quarter.

Monitoring stations are placed near the site boundary and approximately five miles from the reactor, in locations representing the sixteen compass sectors. Other locations are chosen to measure the radiation field at places of special interest such as nearby residences, meeting places and population centers.

Control sites are located further than ten miles from the site, in areas that should not be affected by plant operations.

TLD measurements register the gamma ray exposure in milliRoentgen (mR). For reporting purposes mR is numerically equivalent to mrem. Consequently the terms are used interchangeably.

A total of 214 TLD measurements were made in 2000. The average quarterly dose at indicator locations was 18.1 mrem. At control locations the average quarterly dose was 17.2 mrem. These quarterly measurements ranged from 13.2 to 20.9 mrem for indicator TLDs and 14.1 to 18.7 mrem for control TLDs.

Figure 8 compares the 2000 quarterly TLD results with preoperational TLD quarterly averages.

Average doses (±2 standard deviations), broken down by calendar quarter, are shown in Table 4 for both indicator and control locations.

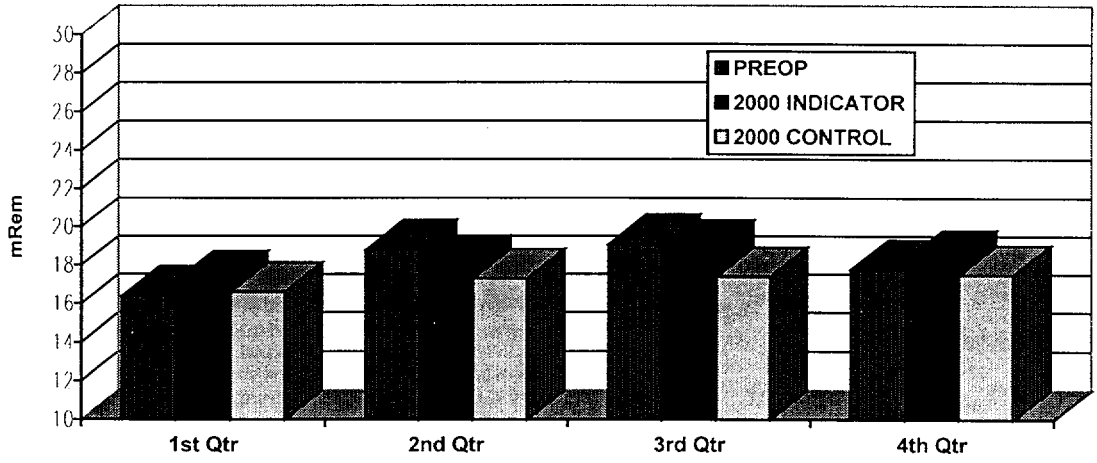
TABLE 4

AVERAGE QUARTERLY TLD RESULTS

Average ± 2σ (mR/quarter)

QUARTER	1999 INDICATOR	2000 INDICATOR	PREOP ALL SITES
1st	16.9 ± 3.5	17.2 ± 2.7	16.4 ± 2.9
2nd	17.9 ± 2.8	18.0 ± 2.8	18.8 ± 3.2
3rd	18.3 ± 3.2	18.8 ± 3.2	19.1 ± 4.7
4th	18.8 ± 3.2	18.3 ± 2.8	17.8 ± 2.2
QUARTER	**1999 CONTROL**	**2000 CONTROL**	**PREOP ALL SITES**
1st	16.2 ± 3.2	16.6 ± 4.0	16.4 ± 2.9
2nd	17.5 ± 3.3	17.3 ± 2.4	18.8 ± 3.2
3rd	17.4 ± 3.4	17.4 ± 2.8	19.1 ± 4.7
4th	17.8 ± 2.7	17.5 ± 2.6	17.8 ± 2.2

Figure 8: DIRECT RADIATION COMPARISON



From these observations, no increase in environmental gamma radiation levels resulted from operation of the Clinton Power Station.

C. Atmospheric Monitoring

The inhalation and ingestion of radionuclides in the air is a direct exposure pathway to man. A network of ten active air samplers around the Clinton Power Station monitors this pathway. There are nine indicator air sampling stations strategically located in areas that are most likely to indicate effects due to the release of radioactive effluents from the Clinton Power Station. The control location is located approximately 16 miles south of the plant in an area that is likely to be independent of the effects of station operations. Historical meteorological data indicates this control location is normally upwind from the plant.

Mechanical air samplers are used to draw a continuous volume of air through a filter and charcoal cartridge to collect particulates and radioiodines present in the atmosphere. The samplers are equipped with a pressure-sensing flow regulator to maintain a constant sampling flow rate of about one cubic foot per minute. The total volume is calculated based on the amount of time the air sampler ran and its flow rate. The air sampling equipment is maintained and calibrated by the Clinton Power Station personnel using reference standards traceable to the National Institute of Standards and Technology.

Air samples are collected weekly and analyzed for gross beta and I-131 activities. Quarterly, all air particulate filters collected during that period are combined and counted for gamma isotopic activity. Since the intent of particulate sampling is to measure airborne radioactivity released from the plant, the counting of short-lived daughters produced by the decay of natural radon and thoron may mask plant contributions. Therefore, the filters are not analyzed for at least five days after their collection to allow for the decay of the short-lived daughters, thereby reducing their contribution to gross beta activity.

Results of the gross beta airborne particulate analyses provided comparisons between indicator and control locations for the year, as well as comparisons between locations in relation to spatial and temporal differences. The calculated annual average was 0.027 pCi/m^3 for all indicator locations and 0.027 pCi/m^3 for the control location. These results are consistent with the preoperational averages for both indicator and control locations that were 0.027 pCi/m^3.

The location with the highest calculated annual average was indicator location CL-3 which is located 0.7 miles northeast of the Clinton Power Station. This location had

an average concentration of 0.028 pCi/m^3. Individual location averages for the year are presented in Table 5.

Minor fluctuations in the gross beta concentrations were noted throughout the year. The general trend for average weekly gross beta concentrations in the indicator locations correlated to the trend for control locations throughout the monitoring period. This correlation is evidenced by the similarity of the trends in the average monthly gross beta concentrations displayed in Figure 9. No significant difference was indicated between individual locations. Monthly averages for indicator and control locations for the year are presented in Table 6.

Fluctuations observed in the gross beta activity over the year can be attributed to changes in the environment, especially seasonal changes.

All gross beta concentrations for the year were within normal background levels and no increases were noted as a result of the operation of the Clinton Power Station.

Naturally occurring Be-7 was the only gamma-emitting radionuclide detected in analyses of particulate filters.

No contribution to the general level of airborne particulate radioactivity could be identified as a result of station operations. The radioactivity that was detected is normally found in the environment and is consistent with expected concentrations of natural radioactivity and fallout from prior atmospheric nuclear weapons testing.

TABLE 5

ANNUAL AVERAGE GROSS BETA CONCENTRATIONS IN AIR PARTICULATES

Average ± 2σ (pCi/m^3)

Station	Description	1999	2000
CL-1	Camp Quest (Birkbeck)	0.024 ± 0.016	0.027 ± 0.021
CL-2	CPS Main Access Road	0.026 ± 0.018	0.027 ± 0.021
CL-3	CPS Secondary Access Road	0.025 ± 0.016	0.028 ± 0.022
CL-4	0.8 miles SW	0.025 ± 0.018	0.027 ± 0.022
CL-6	CPS Recreation Area	0.025 ± 0.018	0.027 ± 0.022
CL-7	Mascoutin State Recreation Area	0.024 ± 0.017	0.025 ± 0.019
CL-8	DeWitt Cemetery	0.025 ± 0.017	0.026 ± 0.021
CL-11[a]	IP Substation (Argenta)	0.026 ± 0.017	0.027 ± 0.019
CL-15	0.9 miles N	0.025 ± 0.016	0.026 ± 0.021
CL-94	Old Clinton Road (0.6 miles E)	0.024 ± 0.016	0.027 ± 0.023

(a) Control Station

TABLE 6

AVERAGE MONTHLY GROSS BETA CONCENTRATIONS IN AIR PARTICULATES

Average ± 2σ (pCi/m^3)

MONTH	1999 Indicator	2000 Indicator	1999 Control	2000 Control
January	0.027 ±0.006	0.034 ±0.002	0.025 ±0.015	0.035 ±0.016
February	0.019 ±0.003	0.030 ±0.002	0.016 ±0.003	0.030 ±0.018
March	0.020 ±0.003	0.020 ±0.001	0.018 ±0.003	0.020 ±0.011
April	0.018 ±0.001	0.018 ±0.003	0.021 ±0.008	0.019 ±0.005
May	0.019 ±0.002	0.021 ±0.002	0.021 ±0.005	0.022 ±0.005
June	0.020 ±0.002	0.019 ±0.002	0.021 ±0.006	0.020 ±0.009
July	0.023 ±0.002	0.022 ±0.004	0.025 ±0.010	0.023 ±0.005
August	0.025 ±0.003	0.027 ±0.002	0.026 ±0.008	0.029 ±0.020
September	0.030 ±0.003	0.022 ±0.002	0.033 ±0.011	0.021 ±0.011
October	0.028 ±0.002	0.034 ±0.004	0.031 ±0.023	0.033 ±0.022
November	0.038 ±0.004	0.034 ±0.004	0.040 ±0.009	0.033 ±0.030
December	0.033 ±0.002	0.038 ±0.005	0.034 ±0.016	0.036 ±0.024

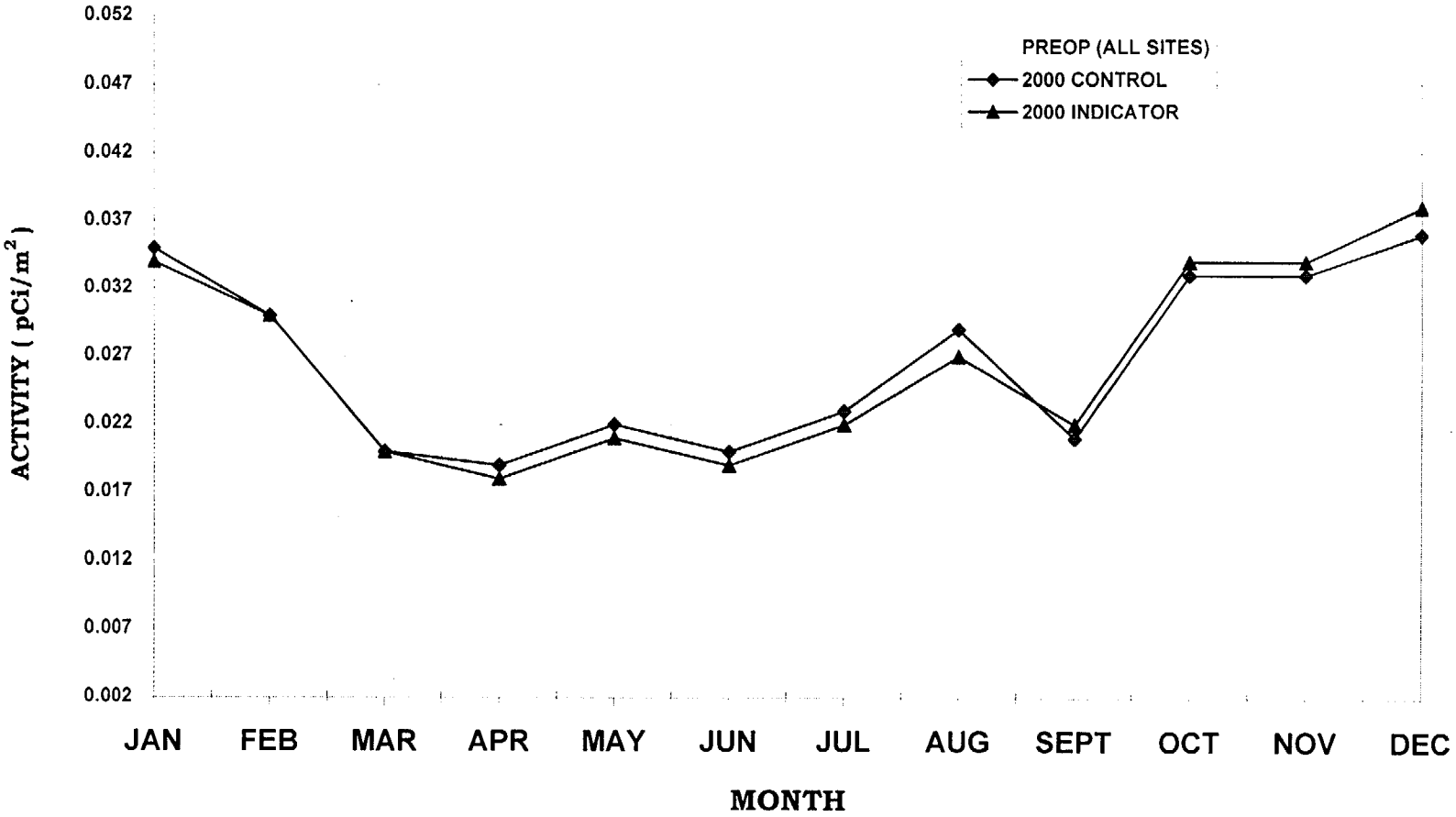


FIGURE 9: AIR PARTICULATE GROSS BETA ACTIVITY COMPARISON

D. Aquatic Monitoring

The Clinton Power Station utilizes a man-made lake as the source of cooling water and returns the used cooling water to the same lake while most nuclear power stations use once-through flow from a river, the ocean or a body of water much larger than Clinton Lake. If radioactive liquid effluents were to be discharged from the Clinton Power Station into the cooling water outfall, radioisotopes with long half-lives could build up as the same water is reused on successive trips through the plant. This water travels from the plant, into the eastern arm of the lake, then into the northern arm of the lake and back into the plant. Although the only user of Clinton Lake as a source of drinking water is the Clinton Power Station, the lake is a major recreational facility, used for fishing, swimming, water skiing, boating and hunting.

Clinton Lake constitutes the primary environmental exposure pathway for radioactive materials in liquid effluents. Aquatic monitoring provides for the collection of fish, shoreline and bottom sediments, and periphyton samples to detect the presence of any radioisotopes related to operation of the Clinton Power Station. These samples are analyzed for naturally occurring and man-made radioactive materials. Both indicator and control locations were sampled. Indicator samples were taken from various locations on Clinton Lake and the control samples were taken at Lake Shelbyville which is approximately 50 miles south of Clinton Power Station.

In addition to naturally occurring radioisotopes, Sr-90 and Cs-137 were found in several samples. However, the concentrations of radionuclides in samples collected near the Clinton Power Station were comparable to the concentrations in samples collected the control location. The presence of these fission products is attributable to previous nuclear weapons testing and fallout from the accident at Chernobyl. The operation of Clinton Power Station had no measurable contribution to the radioactive inventory of the aquatic environment.

Fish

Samples of fish are collected from Clinton Lake and Lake Shelbyville. In both lakes the samples include largemouth bass, crappie, carp and bluegill. These species are the fish most commonly harvested from the lakes by sport fishermen. Fish ingest sediments during bottom feeding, or prey on other organisms, which ingest sediments or

otherwise retain radionuclides. Radiological analyses of these fish samples provide information on the potential ingestion of radionuclides by humans via the aquatic pathway. These samples are collected semiannually and analyzed by gamma spectroscopy.

The results of gamma isotopic analysis on the fish samples showed the presence of naturally occurring K-40 in all samples. All other analytical results were less than the lower limit of detection (LLD) for each radionuclide.

Shoreline Sediments

Samples of shoreline sediments are collected at six locations from Clinton Lake and at one location from Lake Shelbyville. Radiological analyses of shoreline sediments provide information on the potential shoreline exposure to humans and for determining long-term trends and accumulation of long-lived radionuclides in the environment. Samples are collected semiannually and analyzed for gross beta, gross alpha, Sr-90 and gamma isotopic activities.

Shoreline sediment samples are dried prior to analysis and the results are reported in pCi/g dry weight. Naturally occurring radioisotopes were present in samples taken at both indicator and control locations. There was one fission product, Cs-137 detected from the indicator locations. The activity detected was not substantially different from that measured during the preoperational period.

	Preop Range (pCi/g dry)	1999 Range (pCi/g dry)	2000 Range (pCi/g dry)
Cs-137	0.015 - 0.045	0.015 - 0.077	0.054

Bottom Sediments

Samples of bottom sediments are collected from Clinton Lake at six locations and Lake Shelbyville at one location. Radiological analyses of bottom sediments primarily provide information about the amount of radionuclides available to predators who feed on the organisms found in bottom sediments. Samples are collected semiannually and analyzed for gross beta, gross alpha, Sr-90 and gamma isotopic activities.

Bottom sediment samples are dried prior to analysis and the results are reported in pCi/g dry weight. Naturally occurring radioisotopes were present in all control and indicator sample locations.

Cs-137 and Sr-90 were detected in samples from both indicator and control locations. Both radioisotopes are fission products.

	Preop Range (pCi/g dry)	1999 Range (pCi/g dry)	2000 Range (pCi/g dry)
Cs-137	0.008 - 1.39	0.054 - 0.44	0.064 - 0.32
Sr-90	0.011 - 0.056	0.015 - 0.043	0.021 - 0.029

Aquatic Vegetation (Periphyton)

Samples of periphyton are collected from five locations in Clinton Lake and one location in Lake Shelbyville. Periphyton (attached algae) are collected from the submerged surface of the permanently anchored buoys or natural substrate. Samples of periphyton are collected semiannually at the control location and analyzed by gamma spectroscopy. Periphyton analyses are performed because of their sensitivity to the presence of radionuclides in the aquatic environment due to bio-magnification.

Periphyton represents one of the earliest links in the food chain and provides information about the amounts of radionuclides available to predators further up the food chain.

Periphyton absorb trace elements and radionuclides directly from water, often concentrating them to levels much higher than the dilute concentrations that occur in the aquatic environment. This is because most algae are coated with a carbohydrate jelly and have a large surface-to-volume ratio. Cell division usually occurs once every one or two days and, as a result, half of the cell wall is a new surface for sorption.

Using periphyton as biomonitors for radionuclides in aquatic systems can be a highly sensitive and qualitatively effective means of environmental monitoring around nuclear power plants that release radioactive effluents to aquatic systems. It enables the Radiological Environmental Monitoring Program to determine the relative presence of radioactivity before it becomes a problem.

The results of the gamma isotopic analyses on periphyton samples from both indicator and control locations detected concentrations of naturally occurring radioisotopes and one fission product, Cs-137. Concentrations for Cs-137 ranged from 0.019 to 0.041 pCi/g(wet). Preoperational results for Cs-137 showed concentrations ranging from 0.042 to 0.15 pCi/g(wet).

	Preop Range (pCi/g wet)	1999 Range (pCi/g wet)	2000 Range (pCi/g wet)
Cs-137	0.042 to 0.15	0.020 - 0.051	0.019 - 0.041

E. Terrestrial Monitoring

In addition to the direct radiation, radionuclides present in the atmosphere expose individuals when deposited on surfaces (e.g., plants and soil) and are subsequently ingested directly by man or indirectly by consumption of animal products (e.g., meat and milk). To monitor this food pathway, samples of green leafy vegetables, grass, milk and meat are analyzed.

Surface vegetation samples are collected from a number of locations for the purpose of monitoring the potential buildup of atmospherically deposited radionuclides. Because the radionuclides of interest, with respect to the Clinton Power Station operations, are also present in the environment as a result of several decades of worldwide fallout or because they are naturally occurring, the presence of these radionuclides is expected in all of the samples collected.

In addition to naturally occurring radioisotopes, Sr-90 and Cs-137 were found in several samples. However, the concentrations of radionuclides in samples collected near the Clinton Power Station were comparable to the concentrations in samples collected at locations remote from the station. The presence of these fission products is attributable to previous nuclear weapons testing and fallout from the accident at Chernobyl. The operation of Clinton Power Station had no measurable contribution to the radioactive concentration of the terrestrial environment.

Milk

There is no known commercial production of milk for human consumption within a five-mile radius of the Clinton Power Station. Milk samples are collected from a dairy located about 14 miles west-southwest of the station (twice a month during May through October and once a month during November through April). These samples are analyzed for I-131, Sr-90 and gamma isotopic activities.

Results of the analyses showed Sr-90 concentrations ranging from 0.2 to 3.2 pCi/l. Strontium-90 analysis in milk was added to the REMP during the operational phase of the program, therefore there were no preoperational data for this isotope. I-131 was not detected in any of the milk samples collected.

	Preop Range (pCi/g dry)	1999 Range (pCi/g dry)	2000 Range (pCi/g dry)
Sr-90	No Data	0.8 - 1.7	0.2 - 3.2

Grass

In addition to milk samples, grass samples are collected at three indicator locations and at one control location. These samples are collected twice a month during May through October and once a month during November through April (when available). Grass samples are analyzed for gamma isotopic activity including I-131.

The results of the analyses showed only naturally occurring Be-7 and K-40 in these samples. Iodine-131 was not detected in any of the grass samples collected.

Vegetables

The Clinton Power Station obtains broadleaf vegetable samples from three indicator locations and at one control location. The indicator locations are located in the sectors with the highest potential for surface deposition and the control location is in a sector and at a distance which is considered to be unaffected by plant operations. Samples are collected once a month during the growing season (June through September) and analyzed for gross beta and gamma isotopic activities including I-131.

The results of the gamma isotopic analysis showed only naturally occurring K-40 and Be-7.

Iodine-131 was not detected in any vegetable samples collected.

Meat

As an additional check on the presence of radioactive materials in terrestrial exposure pathways, annual samples of beef liver, beef thyroid and edible beef portions are collected from an animal raised near the Clinton Power Station. These samples are analyzed for gamma isotopic activity including I-131.

The results of the gamma isotopic analysis showed only naturally occurring K-40 in all three samples. I-131 was not detected in the meat samples collected.

F. Water Monitoring

Water monitoring provides for the collection of drinking water, surface water and ground water (well water) samples to detect the presence of any radioisotopes related to the operation of the Clinton Power Station.

The only identified user of water from Clinton Lake for domestic purposes is the Clinton Power Station. Samples taken were analyzed for naturally occurring and man-made radioactive isotopes. Average gross beta concentrations in surface, drinking and well water are presented in Table 7 at the end of this section.

Water monitoring results show no measurable effects resulting from the operation of the Clinton Power Station.

Drinking Water

A composite water sampler located in the Service Building collects a small, fixed volume sample at hourly intervals. The sampler discharges each sample into a common sample collection bottle. Therefore, the monthly sample analyzed by the contracted laboratory service is a composite of the individual samples collected throughout the month. The monthly composite sample is analyzed for gross alpha, gross beta and gamma isotopic activities. A portion of each monthly sample is mixed with the other monthly samples collected during each calendar quarter. The quarterly composite sample is analyzed for tritium.

Gross beta activity ranged from 0.9 to 1.8 pCi/l. These levels are attributed to very fine particles of sediment containing K-40 which are not removed during the chlorinating and filtration process.

The results of all analyses for tritium and gamma-emitting radioisotopes were all less than the lower limit of detection.

Surface Water

Composite water samplers are installed in three locations to sample surface water from Clinton Lake. These samplers collect a small volume of water at regular intervals and discharge it to a large sample collection bottle. These bottles are collected monthly.

Two of the composite samplers are located upstream from Clinton Power Station and are unaffected by plant liquid releases downstream. The other composite sampler is positioned to sample the water released from the plant at

the start of the plant discharge flume. Grab samples were collected from one indicator location on Clinton Lake.

Surface water samples are analyzed for gross beta, gamma isotopic and tritium activities. Additional analyses for gross alpha activity are performed on the upstream water samples. Additional analyses for gross alpha activity and I-131 activity are performed on water samples taken from the discharge flume. Tritium analyses are performed quarterly from composites of monthly samples from all composite sample locations.

Results of all gross beta analyses ranged from 1.5 to 4.8 pCi/l for the composite samples, and 1.9 to 3.2 pCi/l for the grab samples. Preoperational gross beta activity ranged from 1.1 to 7.6 pCi/l. These results are attributed to naturally occurring K-40 suspended as fine sediment particles in water. Other types of samples have confirmed the presence of K-40 in Clinton Lake shoreline and bottom sediments.

Tritium analyses performed on samples were all less than LLD. The preoperational tritium concentrations ranged from 220 to 330 pCi/l. As noted in reference (EI87), previous nuclear weapons testing increased the pre-1960 levels of tritium (6-24 pCi/l) by a factor of approximately fifty (300-1200).

Gamma-emitting radioisotopes were all below the lower limits of detection, and there was no iodine-131 detected in any surface water samples collected.

Well Water

Every two weeks samples were collected from the well serving the Village of DeWitt (both treated and untreated samples are obtained) and from a well serving the Illinois Department of Conservation at the Mascoutin State Recreational Area. After the first quarter, the sampling frequency was changed to quarterly as required by the CPS ODCM. Each sample is analyzed for I-131, gross alpha, gross beta, tritium and gamma isotopic activities.

Results of the gross beta analyses ranged from 2.0 to 4.0 pCi/l. Preoperational gross beta activity ranged from 1.1 to 5.1 pCi/l. The gross beta activity was attributed to naturally occurring K-40 suspended as fine sediment particles in water

Gamma-emitting radioisotopes were all below the lower limits of detection. Tritium and I-131 were not detected in any well water samples collected.

TABLE 7

AVERAGE GROSS BETA CONCENTRATIONS IN DRINKING, SURFACE AND WELL WATER

Average ±2σ (pCi/l)

STATION	DESCRIPTION	1999	2000
	Drinking Water		
CL-14	CPS (Service Building)	1.1 ± 0.8	1.2 ± 0.5
	Surface Water		
CL-13	Salt Creek (below dam)	2.3 ± 0.8	2.5 ± 0.9
CL-90	CPS Discharge Flume	2.6 ± 3.0	2.6 ± 1.1
CL-91	Parnell Boat Access	2.2 ± 2.5	2.3 ± 1.4
CL-99	North Fork Canoe Access	4.0 ± 4.8	3.1 ± 2.1
	Well Water		
CL-7D	Mascoutin State Recreation Area	1.5 ± 0.3	2.0*
CL-12(T)	DeWitt Pump Station	3.0 ± 0.8	2.9 ± 0.9
CL-12(U)	DeWitt Pump Station	3.4 ± 1.2	2.1*

(U) Untreated (T) Treated

* only one result

G. Quality Assurance Program

To establish confidence that data developed and reported are accurate and precise, all REMP activities are incorporated into the AmerGen Company Quality Assurance (QA) program of audits and surveillances. The Quality Assurance program requires:

- Participation in intercomparison programs, such as the Environmental Resource Associates (ERA) cross-check program.
- Audits of the analysis laboratory functions and facilities.
- Periodic review of the Clinton Power Station procedures specifying sampling techniques.
- Duplicate analysis of all samples received (not including TLDs). This requirement is to check laboratory precision.
- The routine counting of quality control samples.

The analytical results provided by the laboratory were routinely reviewed to ensure the required minimum sensitivities have been achieved and the proper analyses have been performed.

Environmental Inc. has participated in interlaboratory comparison (crosscheck) programs since the formulation of it's quality control program in December 1971. These programs are operated by agencies which supply environmental type samples (e.g., milk or water) containing concentrations of radionuclides known to the issuing agency but not to participant laboratories. The purpose of such a program is to provide an independent check on the laboratory's analytical procedures and to alert it to any possible problems.

Results of the 2000 Environmental Inc. cross-check programs are shown in Appendix A.

H. Changes to the REMP During 2000

Occasionally changes to the Radiological Environmental Monitoring Program are necessary to improve the monitoring of the environmental exposure pathways. These changes may result from items identified during the performance of the Annual Land Use Census, revised or new regulatory requirements or Quality Assurance audits.

During 2000, there were no changes to the REMP program as required by the Off-Site Dose Calculation Manual.